Strait of Georgia Juvenile Herring Survey, September 2014

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STRAIT OF GEORGIA JUVENILE HERRING SURVEY, SEPTEMBER 2014

by

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ABSTRACT

Thompson, M., Fort, C., and Boldt, J. 2016. Strait of Georgia juvenile herring survey, September 2014. Can. Manuscr. Rep. Fish. Aquat. Sci. 3087: v + 45 p.

A fall juvenile herring survey of the Strait of Georgia took place September 8th to 30th, 2014. This survey serves to address several questions of early herring survival, abundance, recruitment and trophodynamics. All forty-eight stations were sampled throughout the Strait of Georgia following the ten core transects that have been sampled since 1990. The survey area extends from Trincomali Channel in the south to Smelt Bay in the north. Zooplankton and physical environmental data were also collected in the study area.

RESUME

Thompson, M., Fort, C., and Boldt, J. 2016. Strait of Georgia juvenile herring survey, September 2014. Can. Manuscr. Rep. Fish. Aquat. Sci. 3087: v + 45 p.

Un relevé automnal du hareng juvénile dans le détroit de Georgie a été réalisé entre le 8 et le 30 septembre 2014. Ce relevé visait à répondre à plusieurs questions sur la survie, l'abondance, le recrutement et la trophodynamique du hareng durant les premiers stades de son développement. Les 48 stations situées dans le détroit de Georgie ont été échantillonnées en suivant les 10 transects principaux qui font l'objet d'un échantillonnage depuis 1990. La zone du relevé s'étend du chenal Trincomali au sud jusqu'à Smelt Bay au nord. Des données sur le zooplancton et l'environnement physique ont également été recueillies dans la zone d'étude.

INTRODUCTION

Pacific herring (*Clupea pallasi*) are an important commercial and a vital forage species for many marine mammals, birds, and fish in British Columbia's coastal waters. Herring spawn principally on marine vegetation in the subtidal and upper intertidal zone between February and June, with peak spawning between March and April (Humphreys and Hourston 1978). Larvae hatch after two to three weeks, and disperse with surface currents, metamorphosing into juvenile or young-of-the-year herring at a length of ~25mm (Hourston and Haegele 1980). Herring are considered juveniles or immature until they are about three years of age and have joined the sexually mature spawning population (Hay and McCarter 1999). During daylight hours, juvenile herring congregate in schools, occasionally forming mixed aggregates with other pelagic species, close to shore near the bottom (Haegele 1997). At dusk, these fish migrate into surface waters to feed on plankton. During this time they are vulnerable to purse seine gear.

Purse seine surveys to determine the distribution and abundance of juvenile herring in the Strait of Georgia have been conducted annually since 1990, except for 1995 (Figure 1). The main objective of the survey was to estimate the density and relative abundance of the juvenile herring population. In addition to recruitment prediction, the surveys have contributed to a better understanding of the distribution, relative abundance, and ecological role of herring in the Strait of Georgia.

METHODS

The annual survey of juvenile herring in the Strait of Georgia (Figure 2) followed the ten core sampling transects (1 – 6, 8 – 11); which are made up of 48 sampling stations and have been sampled consistently since 1990 (except 1995). Data from these ten core transects have been used to predict juvenile herring recruitment (Hay et. al. 2003). Originally, the sampling transects were chosen based on known historical herring spawning sites and were roughly placed equal distance apart around the Strait of Georgia. Placement also represents both nearshore and open water habitats (Haegele et. al. 2005). In 2014, sampling was conducted from September 8th to 30th (Table 1). All forty-eight core stations were sampled.

Fish Sampling

In 2014, the 12 m, aluminum-hulled Fisheries Research Vessel *Walker Rock* was used for all fishing events. A 183 m long and 27 m deep purse seine net of knotless web, resulting in an area fished of ~2665 m^2, was used for all fishing events. The body of the net had 46 m of 22.2 mm mesh at the tow end followed by 91 m of 19.0 mm mesh, and the bunt end was 46 m of 9.5 mm mesh. The net fished to a depth of 10 m, and was able to retain fish greater than 20 mm in length. All sets were made after dusk when herring were feeding near the surface. All sets were made at the pre-determined sampling stations. Five sets

were completed per night, depending on location, and length of travel between transects and the marine weather forecast. For most sets, it was possible to land the entire catch for biological sampling. On occasion, it was not practical to land a large set in its entirety, so sub-sampling was necessary. When sub-sampling was required, a 40 kg tote was filled with randomly selected fish and retained for biological sampling. Several dipnet samples were taken from various parts of the net (catch) to make up the random sub-sample. The remainder of the set was released over the corkline, its size (volume) estimated as the number of totes released. All fish retained for sampling were bagged and frozen, with the exception of large predator species (e.g. adult salmon and flatfish). These fish were individually measured in the field. Freezing the biological samples was new for this year, in previous years 3.7% seawater formalin solution was used for preservation. All retained fish were later sampled in the laboratory at the Pacific Biological Station. From each set, up to 100 herring are individually weighed and measured. Up to 25 individuals for all other species caught were identified, weighed and measured. If the set contained fewer than 100 herring, then all herring were weighed and measured. Consistent with standard practices, herring were measured to standard length, salmon to fork length and groundfish to total length; all to the nearest millimetre. All other fish species were measured to standard length. The number of herring caught in each set was determined by dividing the total catch weight by the mean individual fish weights of the subsampled herring. The number of other species caught was determined in the same manner (Tables 3).

Zooplankton Sampling

Nineteen stepped oblique zooplankton tows were performed (Figure 3). Clarke Rock (transect 1, station 1) was skipped due to mechanical malfunction with the plankton net winch. The tows were always completed after dusk and immediately before the fishing events. A nearshore and offshore tow location was sampled on all transects. Dual 19 cm diameter bongo nets with 350 µm mesh were used for sampling, resulting in 'left' and 'right' bongo zooplankton samples (only left samples were processed). The bongos were lowered to 20 m depth (10 m in shallow areas) and raised by an electric winch at a rate of 1 m every 15 sec (or 1 m every 30 sec for shallow areas). The zooplankton tow was performed with the vessel doing a small circle at ~2 knots speed. Each tow took approximately 5 minutes to complete. A General Oceanics® 2030R model flowmeter was attached to the left bongo net to determine the volume of seawater filtered. Volume filtered was calculated using the following equation (McCarter and Hay 2002):

$$\mathbf{V = (A \cdot F \cdot K) / 999{,}999}$$

where:

V = volume of water filtered through the plankton net (m^3)
A = area of net opening (0.02835 m^2)
F = number of revolutions recorded by the flow meter (m)
K = standard speed rotor constant for 7cm rotor (26,873)

Upon retrieval, the bongo nets were washed with a high pressure deck hose to rinse zooplankton into the codends, and the samples were preserved in 3.7 % seawater formalin.

In the laboratory, a volumetric splitter was used to reduce the sample size to where organisms could be conveniently counted and identified in a counting tray using a stereo microscope under 30X magnification. Sample splitting continued until a target size of roughly 300 organisms was reached (Thompson et al. 2003).

Zooplankton was identified to the lowest possible taxonomic level. Copepods were identified to species. Densities for all zooplankton species were determined and expressed as number of animals/ m^3.

CTD Sampling

We used Conductivity Temperature Depth recorder (CTD) casts to characterize oceanographic conditions in the surveyed area. We did twenty casts using a RBR XR-60 CTD at stations where zooplankton was sampled (Figure 3). One CTD cast was performed at each location before zooplankton sampling. The CTD unit was weighted and lowered over the side of the vessel to within ~2 meters of the bottom to give the largest water profile possible. Descent rate of the CTD was close to 1 m/sec. Data from the CTD casts were subsequently downloaded to a laptop at the end of the each evening.

RESULTS

Herring

Forty-eight stations were sampled from transects 1 – 6, 8 – 11. A total of 3284 herring were weighed and measured resulting in a length frequency distribution that was distinctly bimodal for age-0+ and age-1+ herring (Figure 4). Length designations for the juvenile herring age-classes were:

0+ = herring less than or equal to 114 mm standard length
1+ = herring between 115 mm and 154 mm standard length
2+ and older = herring greater than or equal to 155 mm standard length

Catches at forty-three of the forty-eight stations (89.6%) contained age-0+ herring (Table 3). The mean length and weight of age-0+ herring was 88 mm and 9.10 g respectively. A total weight of 255.88 kg and estimated 28506 individual age-0+ herring were caught (Table 4).

Catches at twenty-one of the forty-eight stations (43.8%) sampled contained age-1+ herring (Table 3). The mean length and weight of age-1+ herring was 133 mm and 32.65

g, respectively. A total weight of 772.18 kg and estimated 22461 individual age-1+ herring were caught (Table 4).

Catches at eight of the forty-eight stations (16.7%) sampled contained age-2+ herring (Table 3). The mean length and weight of age-2+ herring was 165 mm and 63.06 g, respectively. A total weight of 261.33 kg and estimated 4170 individual age-2+ herring were caught (Table 4).

Length frequency histograms by transect location for all sampled herring are shown in Figure 5. All transects on the south-east Vancouver Island-side were dominated by age-0+ except Bowser (transect 3, station 1) which had a very large number of age-1+ and age-2+ herring. The mainland transects contained a mixture of age-0+ and age-1+ herring. A length-weight relationship for all sampled herring from the survey showed a significant, positive correlation (R^2=0.9858; Figure 6).

Zooplankton

There were 24 categories of organisms identified in 19 zooplankton samples (Tables 5, 6 and 7). An average of 10.884 m^3 of water was filtered per zooplankton tow. Calanoid copepods (*Paracalanus parvus* and *Calanus sp.*), cyclopoid copepod (*Oithona similis*), larvaceans (*Oikopleura sp.* and *Fritillaria sp.*), and amphipods were the only categories to occur in all samples. More than 55% of all zooplankton biomass comprised cladocerans, larvaceans (*Oikopleura sp.*and *Fritillaria sp.*), and calanoid copepods (*Paracalanus parvus* and *Calanus sp.*).

CTD

Two CTD casts were performed at each transect location before plankton sampling. The CTD provided a range of data for temperature (°C), salinity (ppt), dissolved oxygen (%) and depth (m). Overall, a 10m thermocline can be seen in several casts. Generally, oxygen and salinity show similar patterns as temperature with depth. CTD data collection has been variable throughout the survey time period; therefore, longer term data collection is required to make broader annual oceanographic observations.

CONCLUSION

Forty-eight stations were sampled resulting in 23 different fish species recorded from purse seine sets. A total of 3284 herring were measured and weighed creating a bimodal histogram clearly representing age-0+ and age-1+ juvenile herring. Nineteen zooplankton tows were performed with calanoid copepods (*Paracalanus parvus*, *Calanus sp.*), and larvaceans (*Oikopleura sp.*and *Fritillaria sp.*) being the predominant organisms in numbers and biomass.

ACKNOWLEDGMENTS

The 2014 Strait of Georgia juvenile herring survey was funded by the Pacific Salmon Foundation along with the Department of Fisheries and Oceans. This survey could not have been possible without the hard work and good cheer of skipper Doug Henderson. Thanks to Linnea Flostrand for filling in for a couple evenings of sampling. Zooplankton samples were processed by Zotec services.

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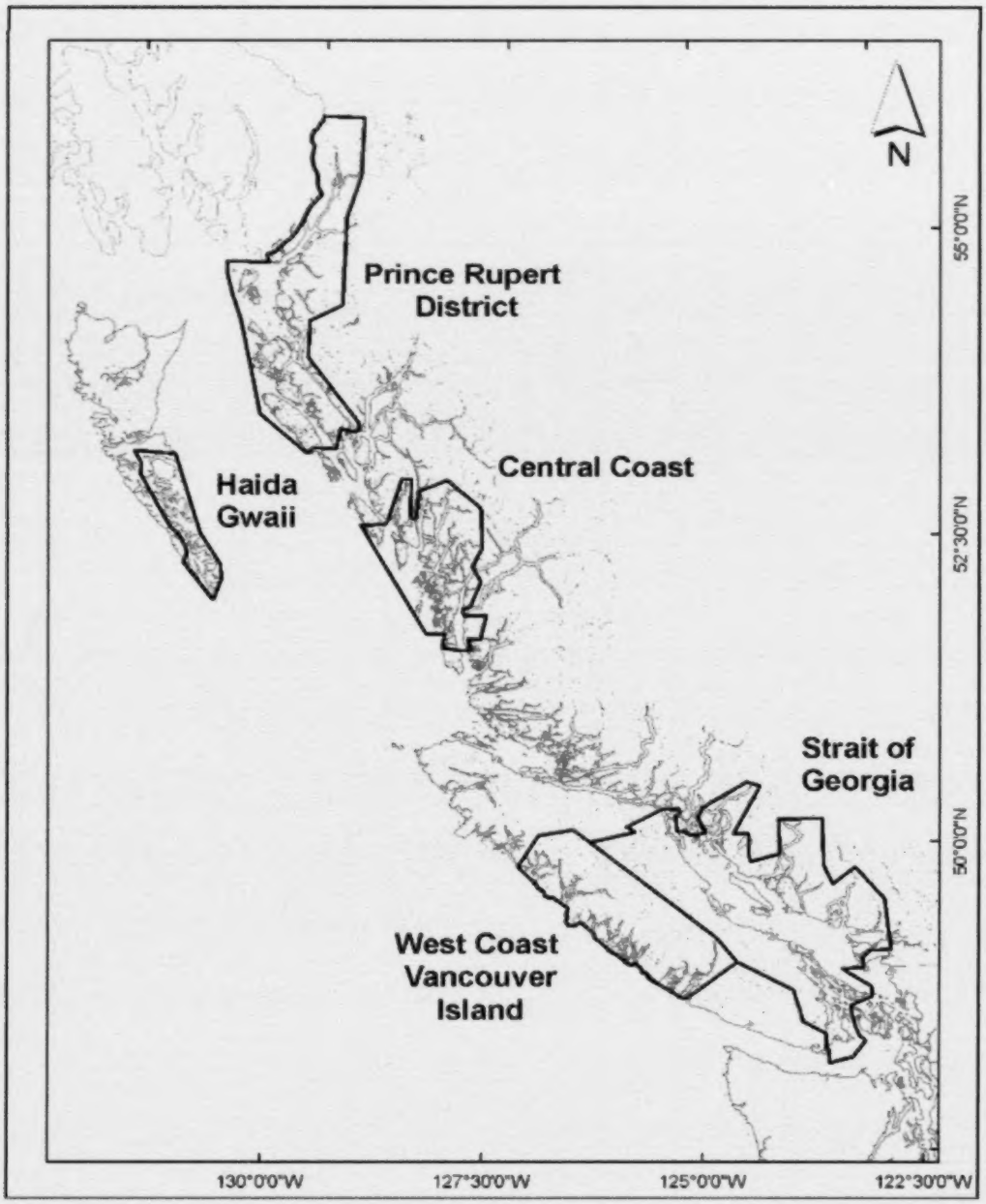


Figure 1. The five major British Columbia herring stock assessment areas.

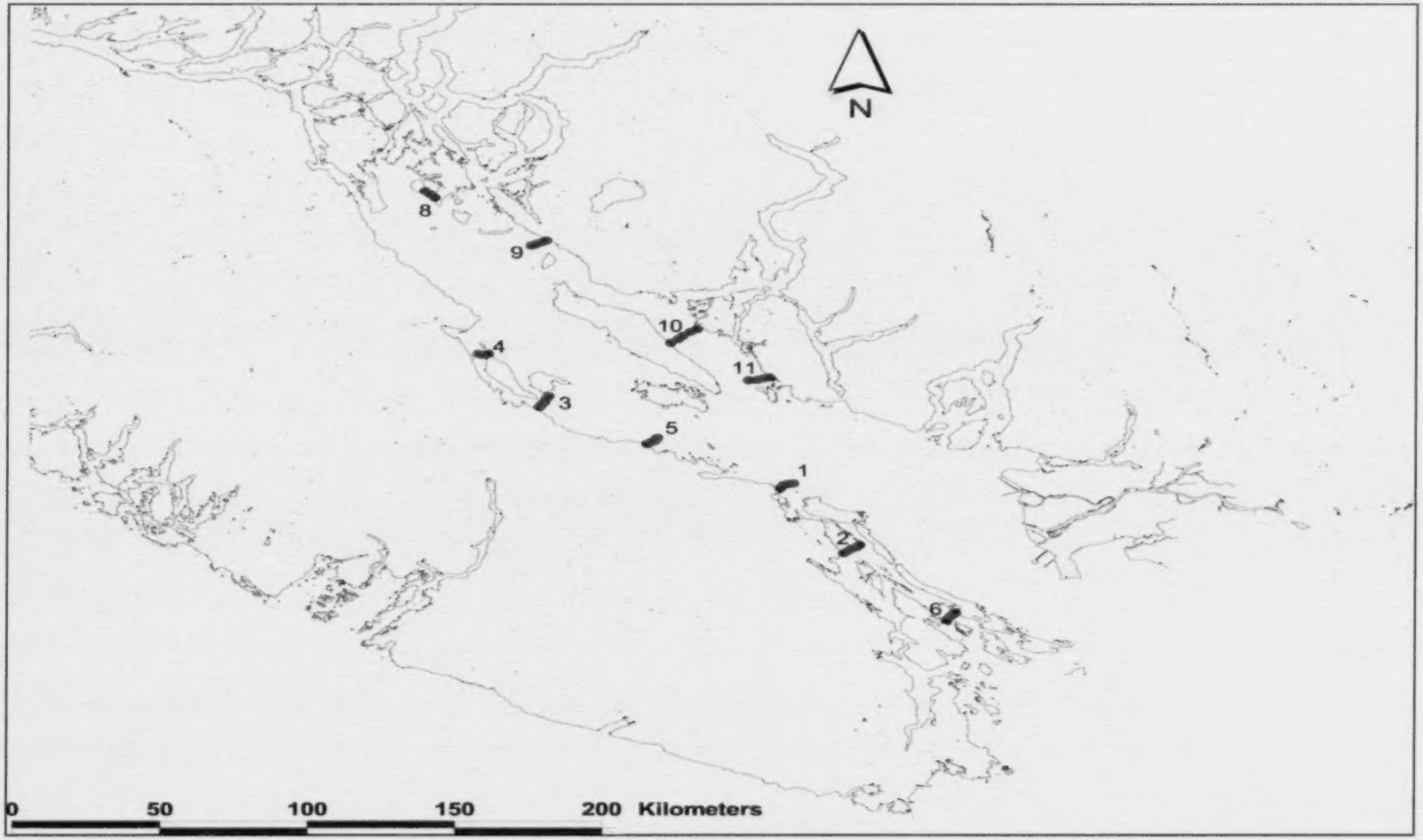


Figure 2. Purse seine set locations for the 2014 Strait of Georgia juvenile herring survey.

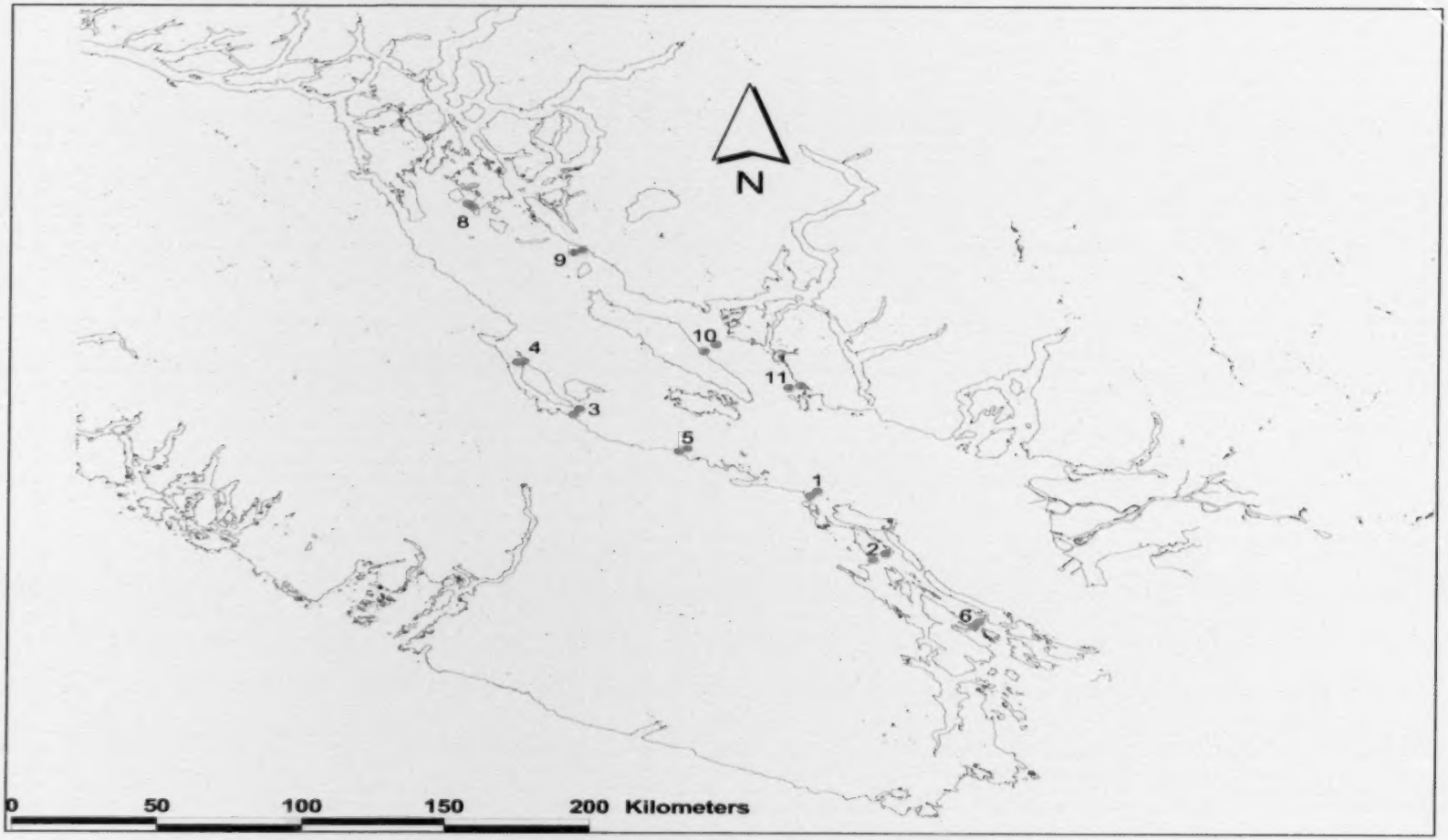


Figure 3. Zooplankton and CTD stations for 2014 Strait of Georgia juvenile herring survey.

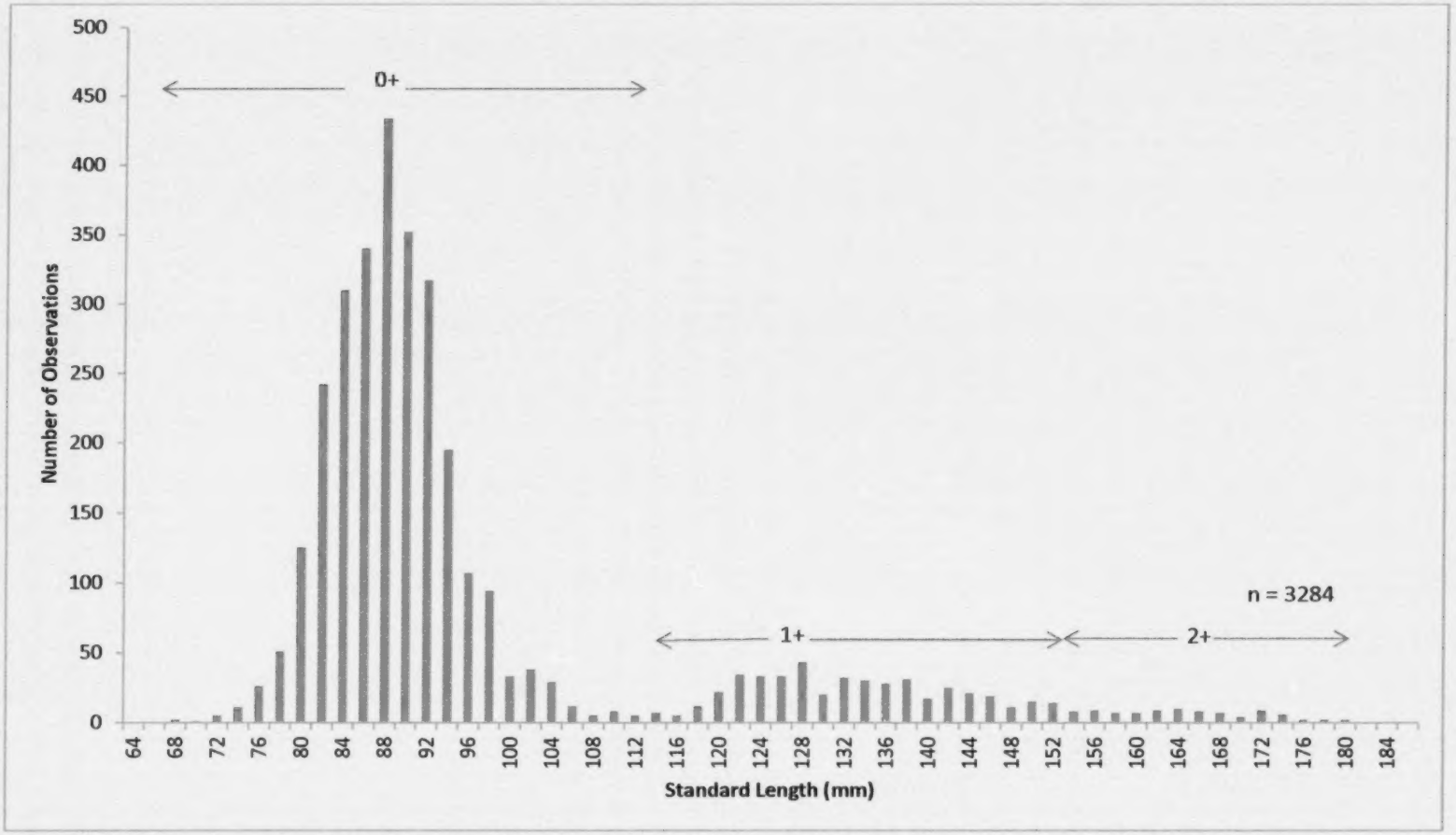


Figure 4. Length-frequency distribution for all herring sampled during the 2014 Strait of Georgia juvenile herring survey.

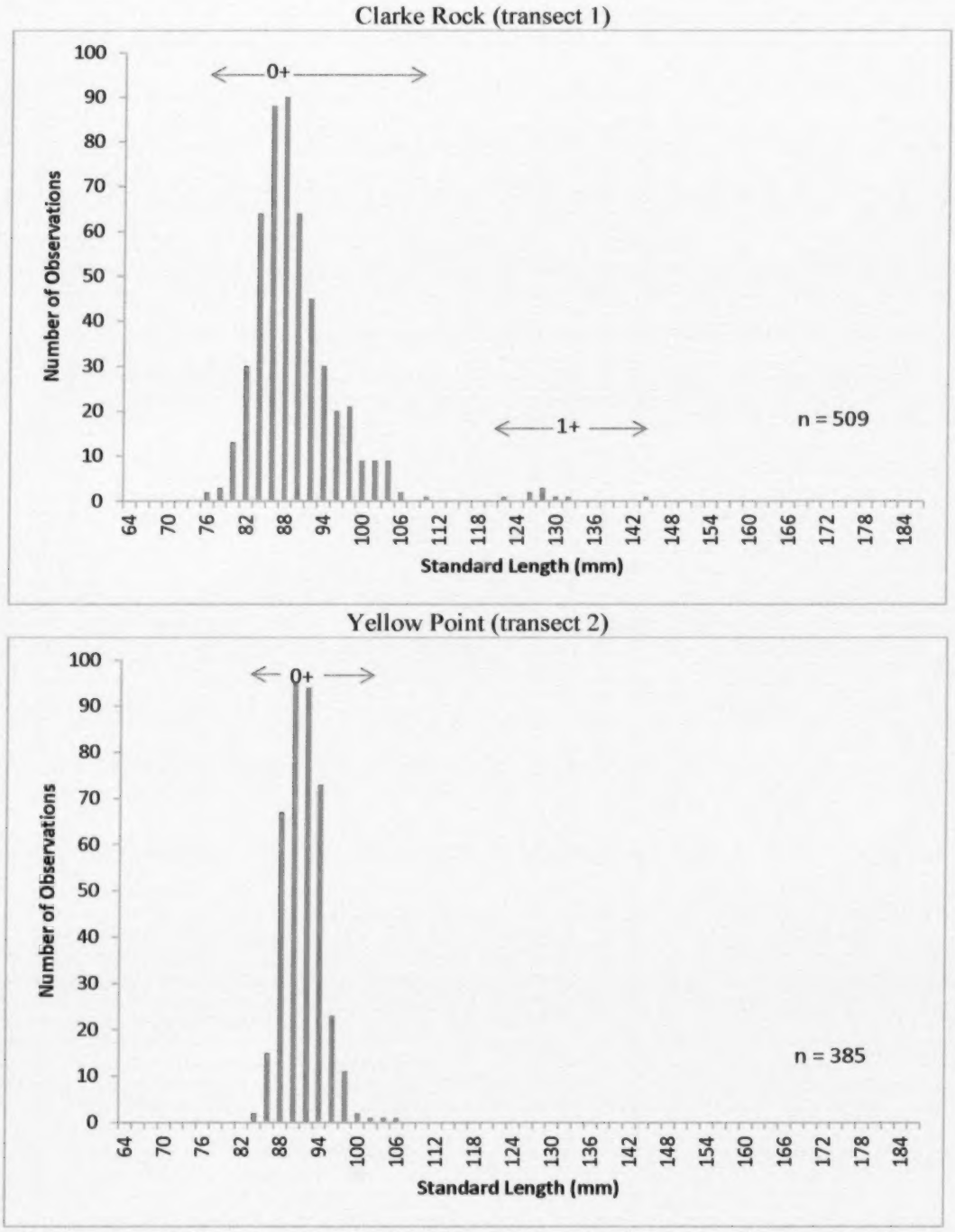
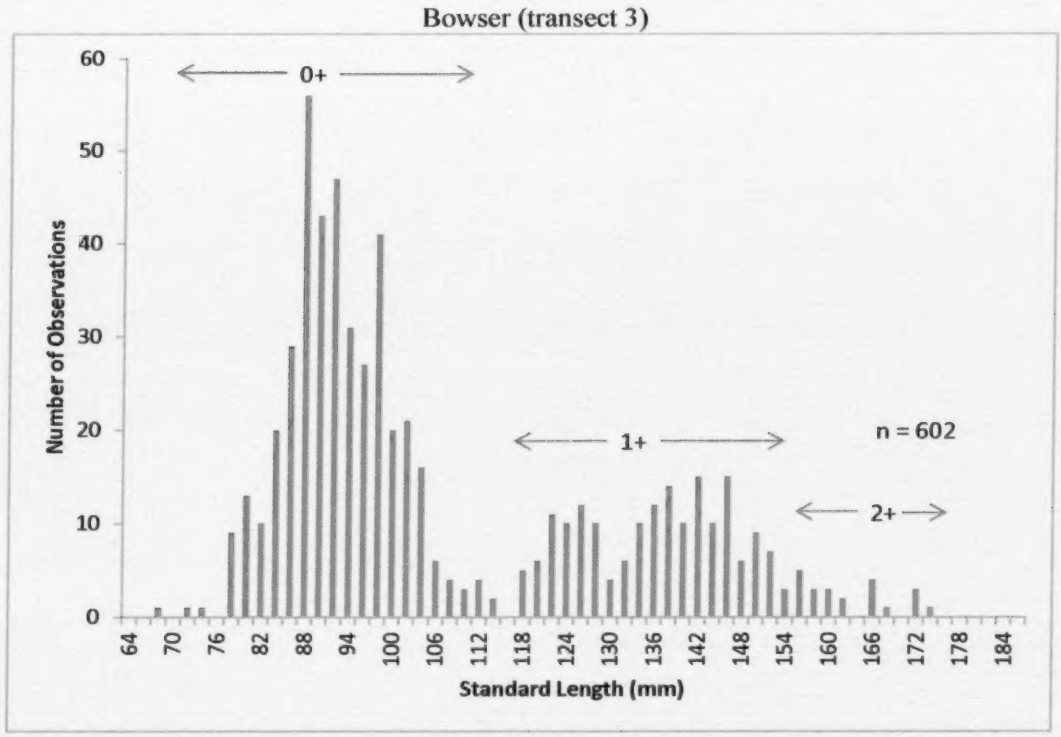
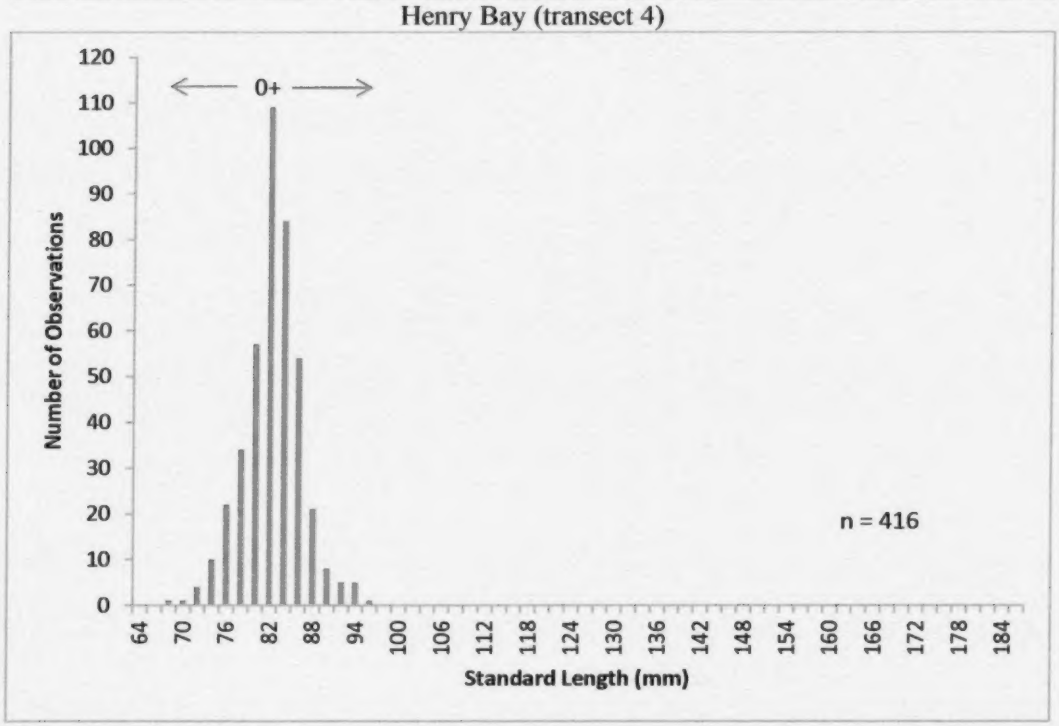


Figure 5. Length-frequency histograms of juvenile herring by transect location for the 2014 Strait of Georgia juvenile herring survey. Transect 5 and 6 are omitted because only 9 and 5 herring were caught respectively.





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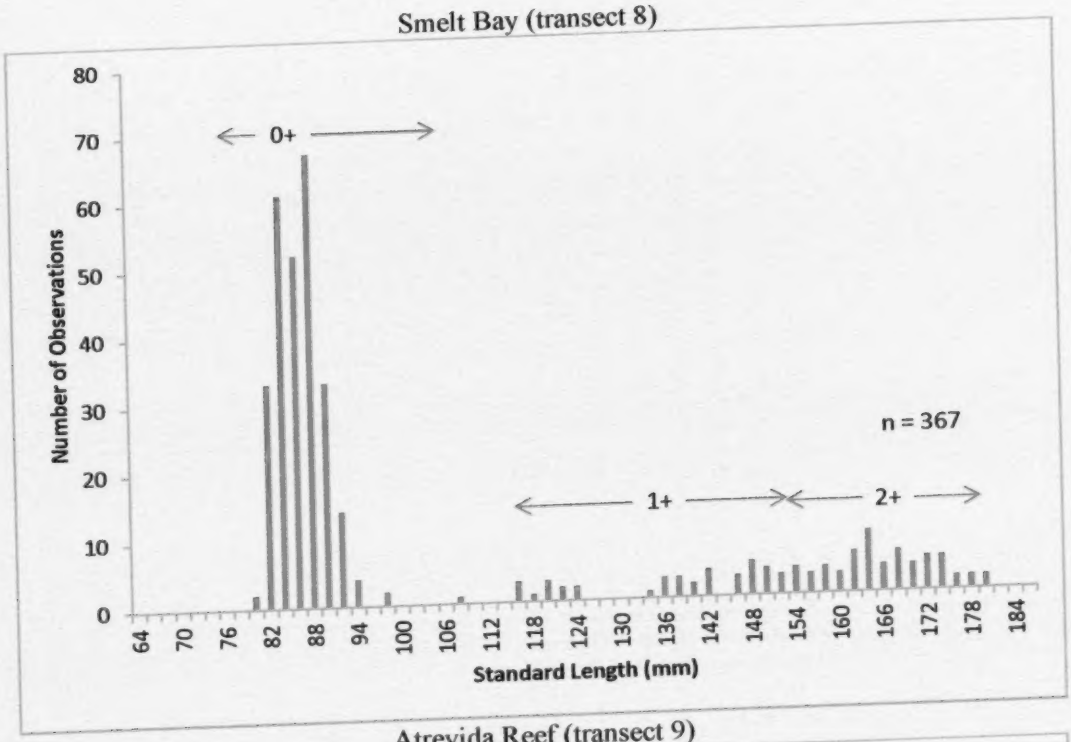

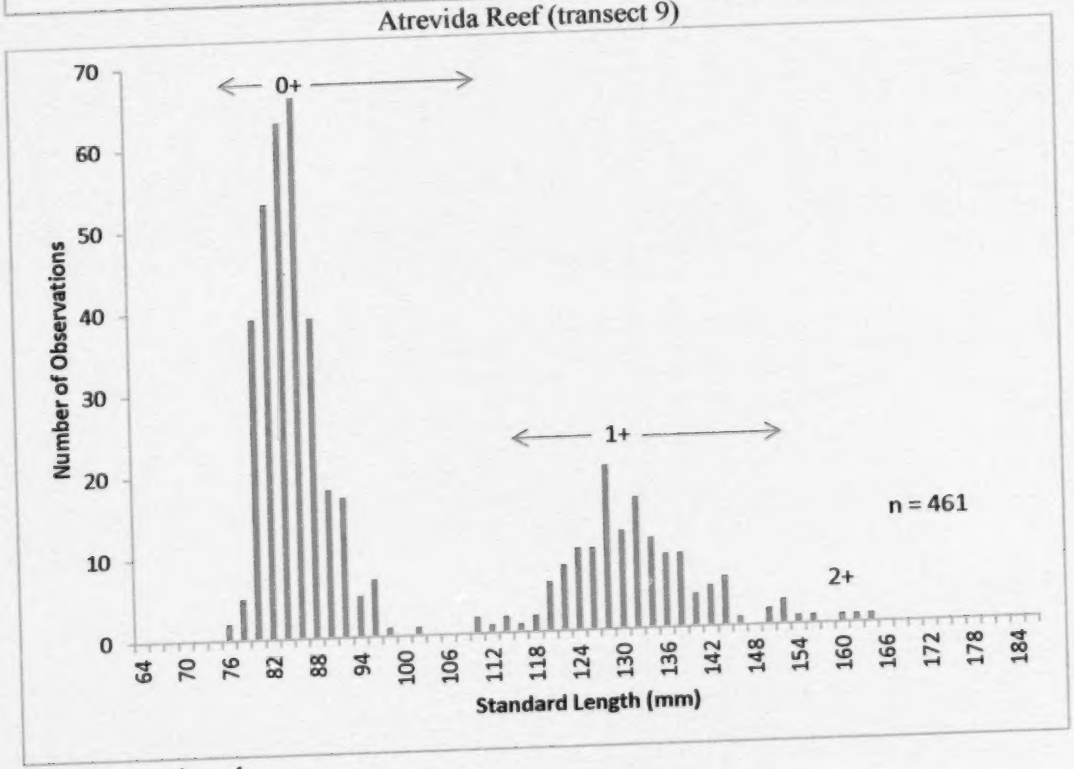

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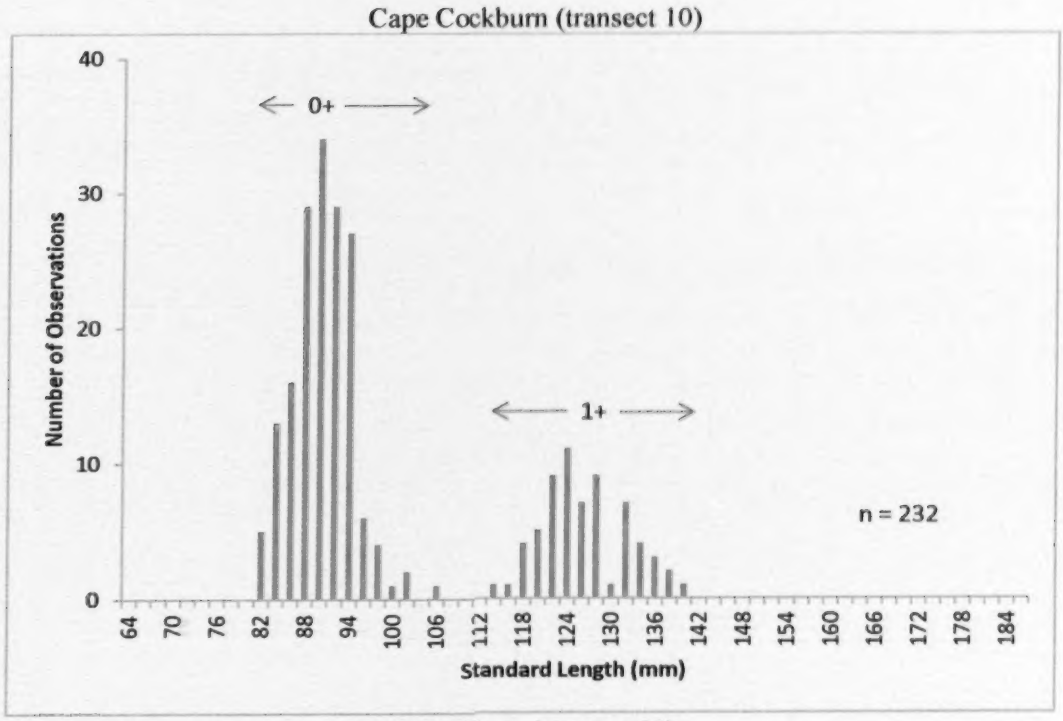

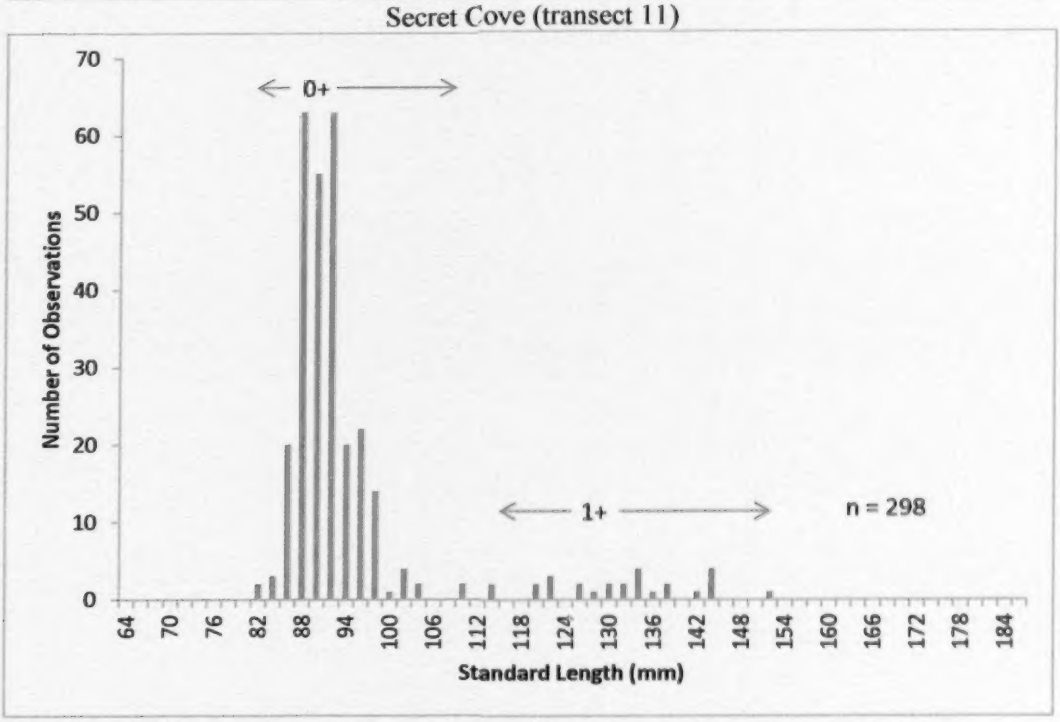

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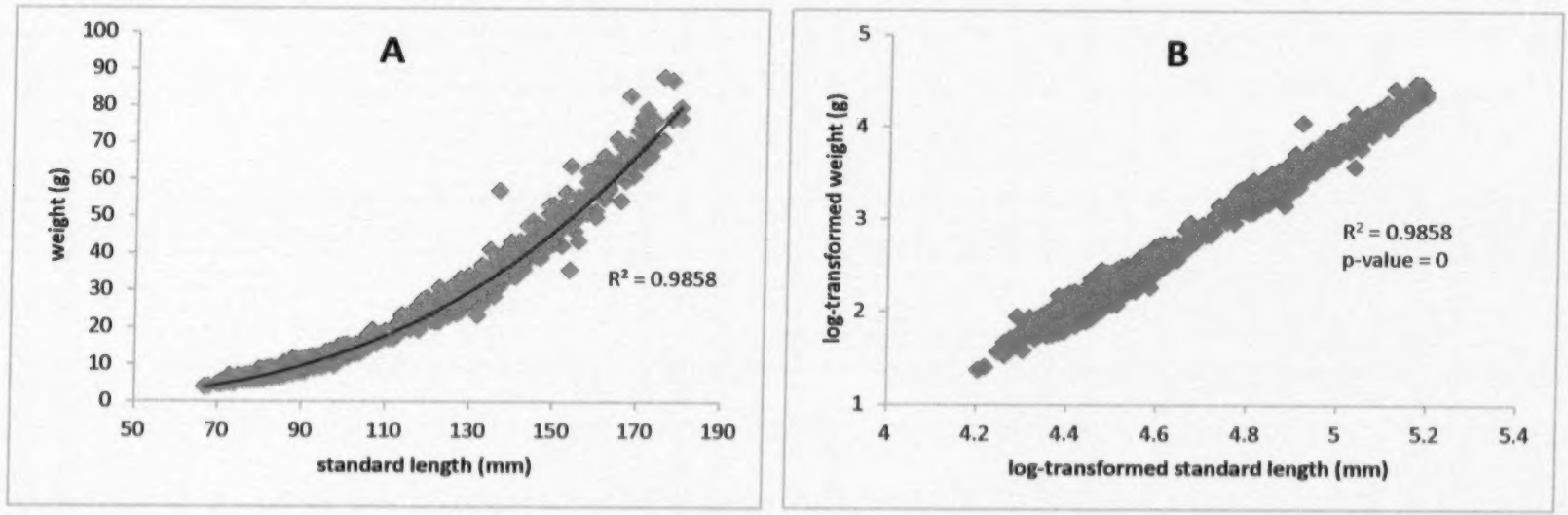


Figure 6. Nontransformed (A) and log-transformed (B) length-weight relationship for all herring sampled during the 2014 Strait of Georgia juvenile herring survey.

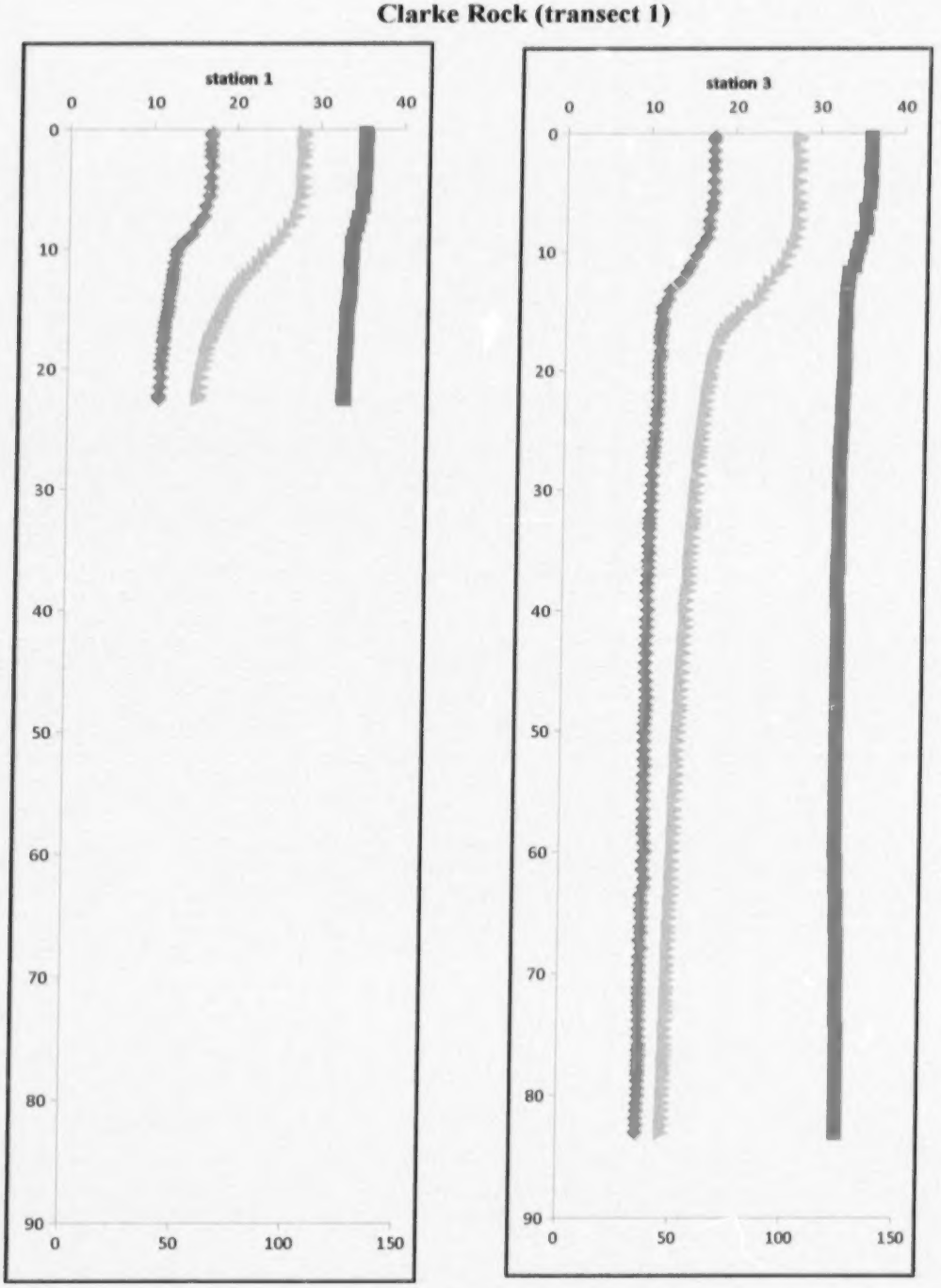
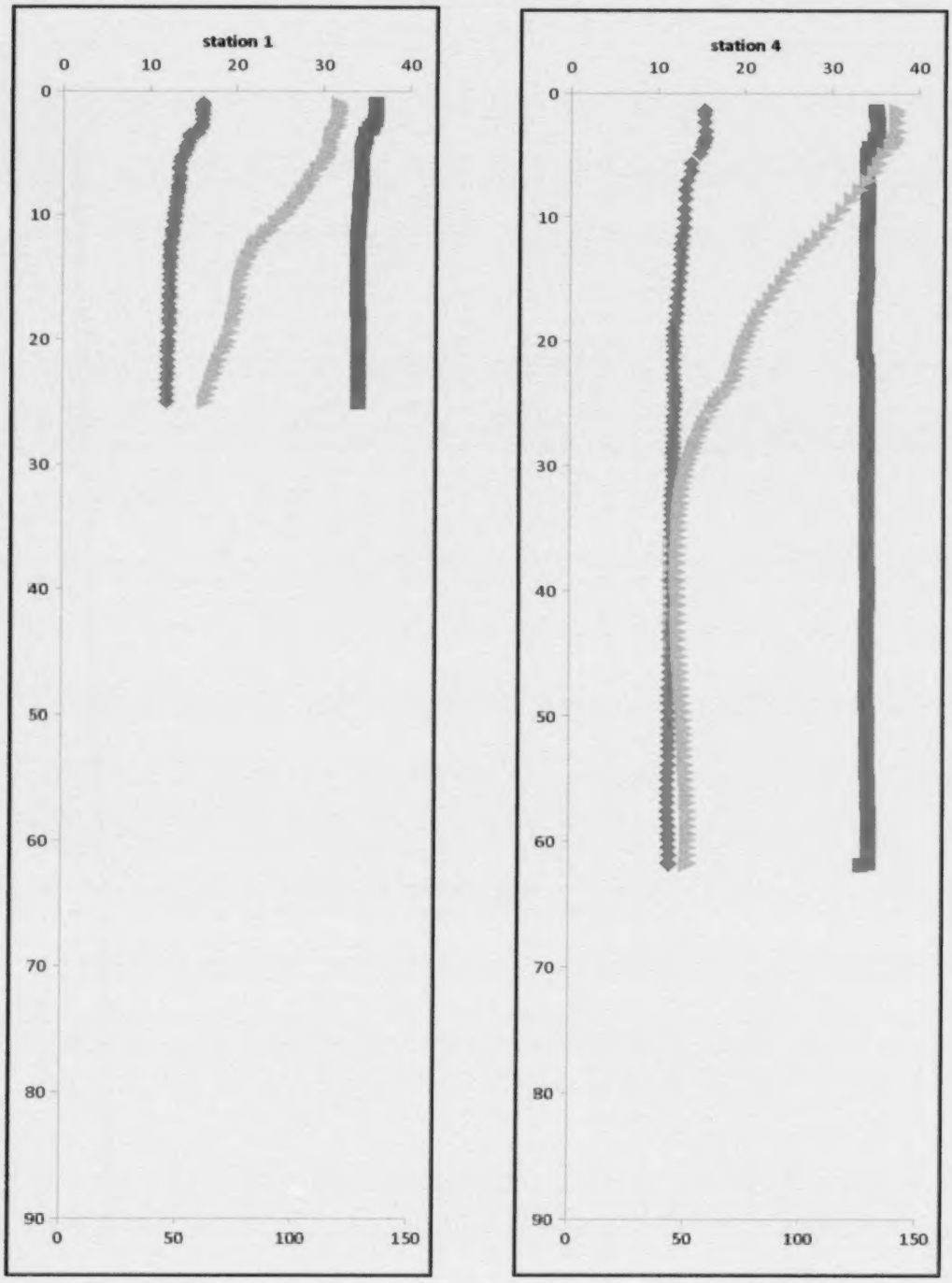


Figure 7. Temperature (blue), salinity (red) and dissolved oxygen (green) profiles from CTD casts during the 2014 Strait of Georgia juvenile herring survey.

Yellow Point (transect 2)



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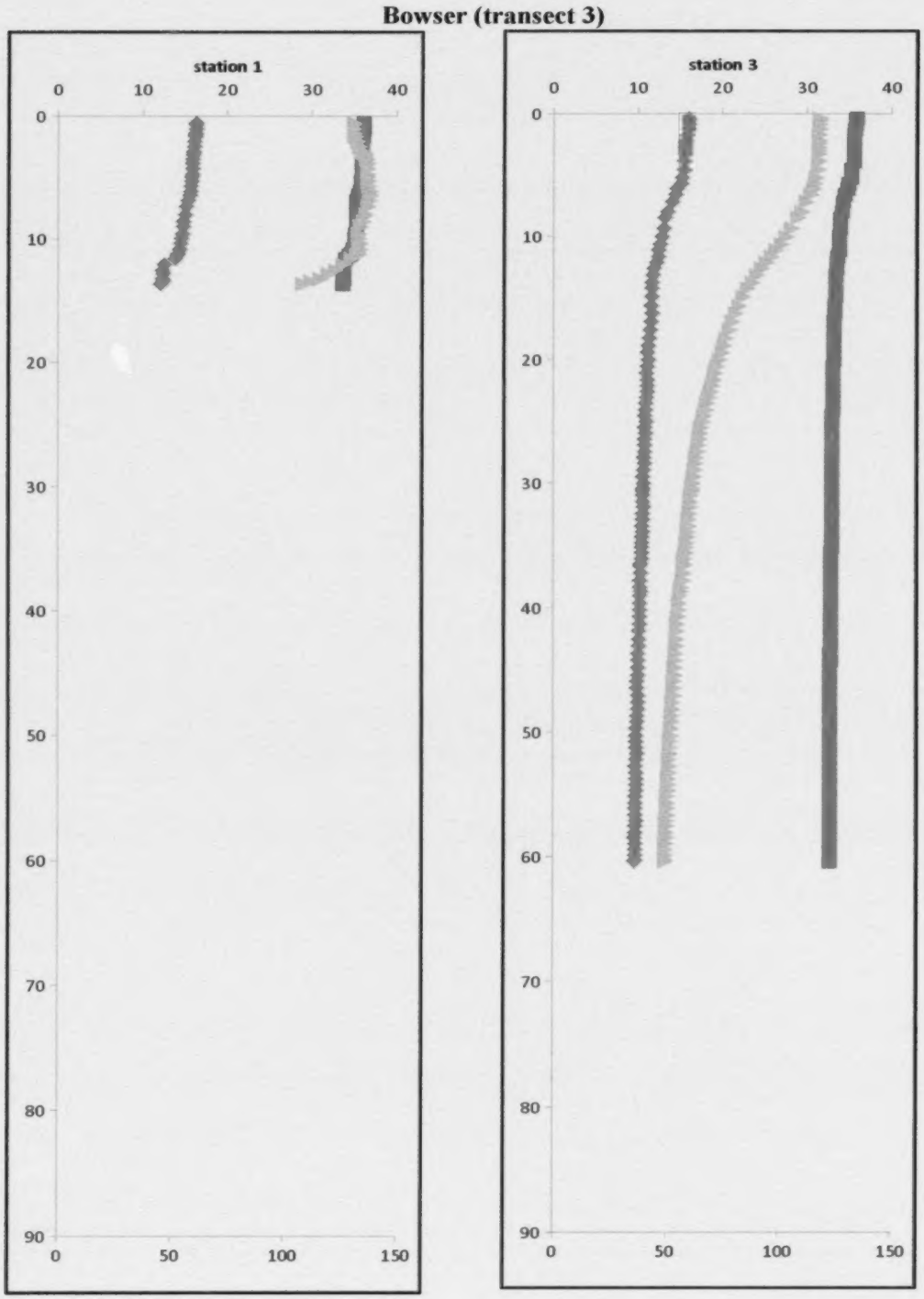

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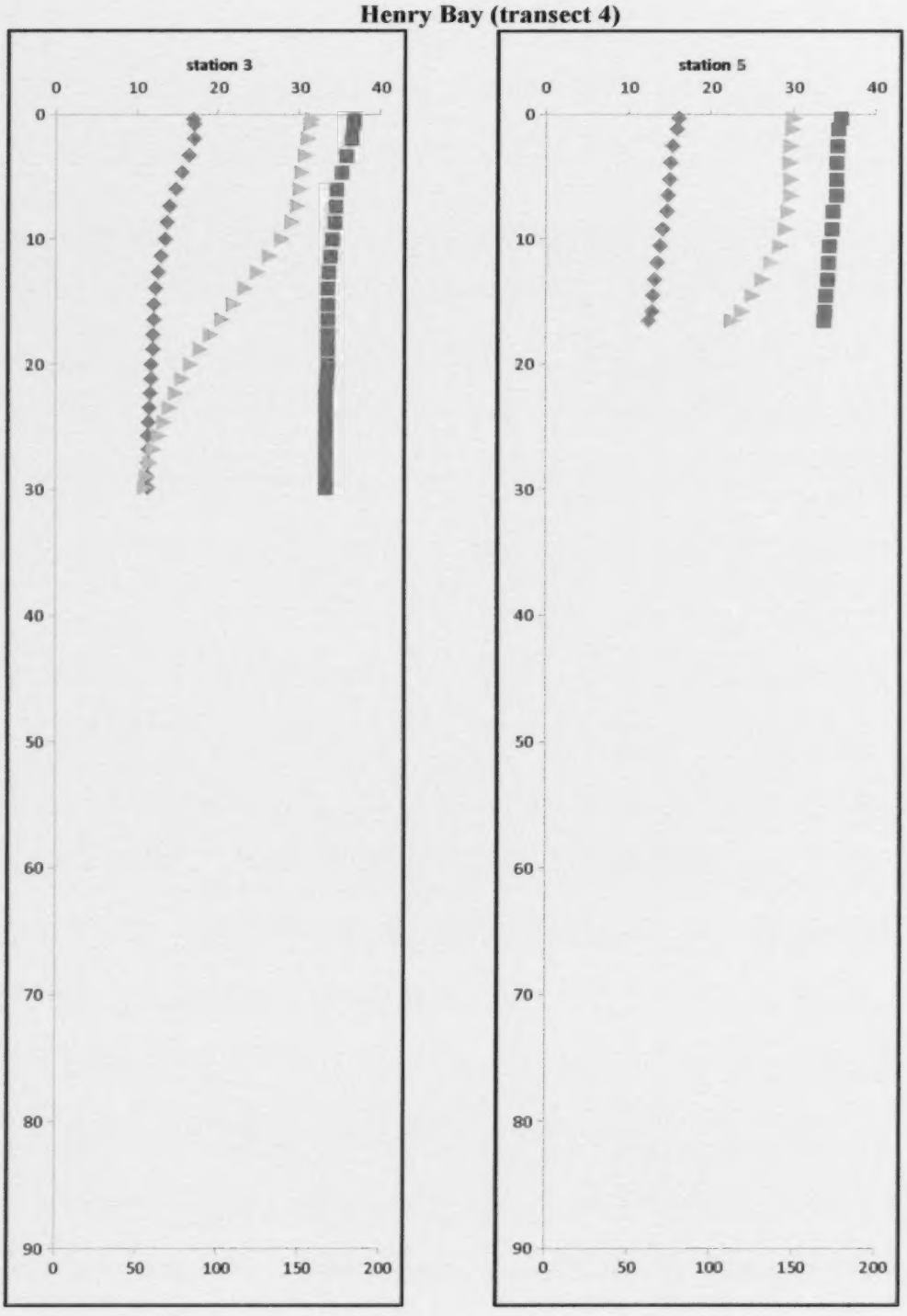

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French Creek (transect 5)

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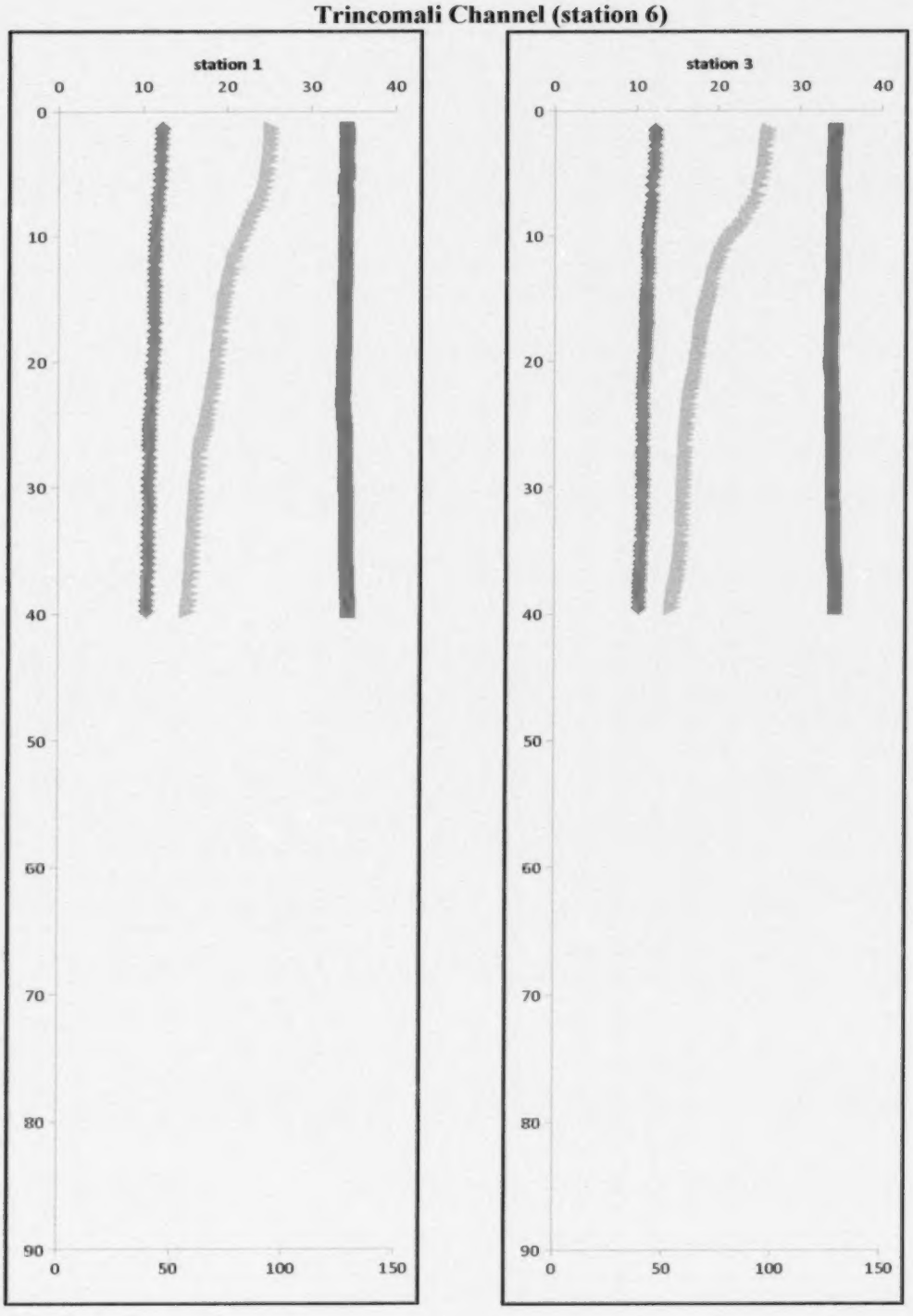

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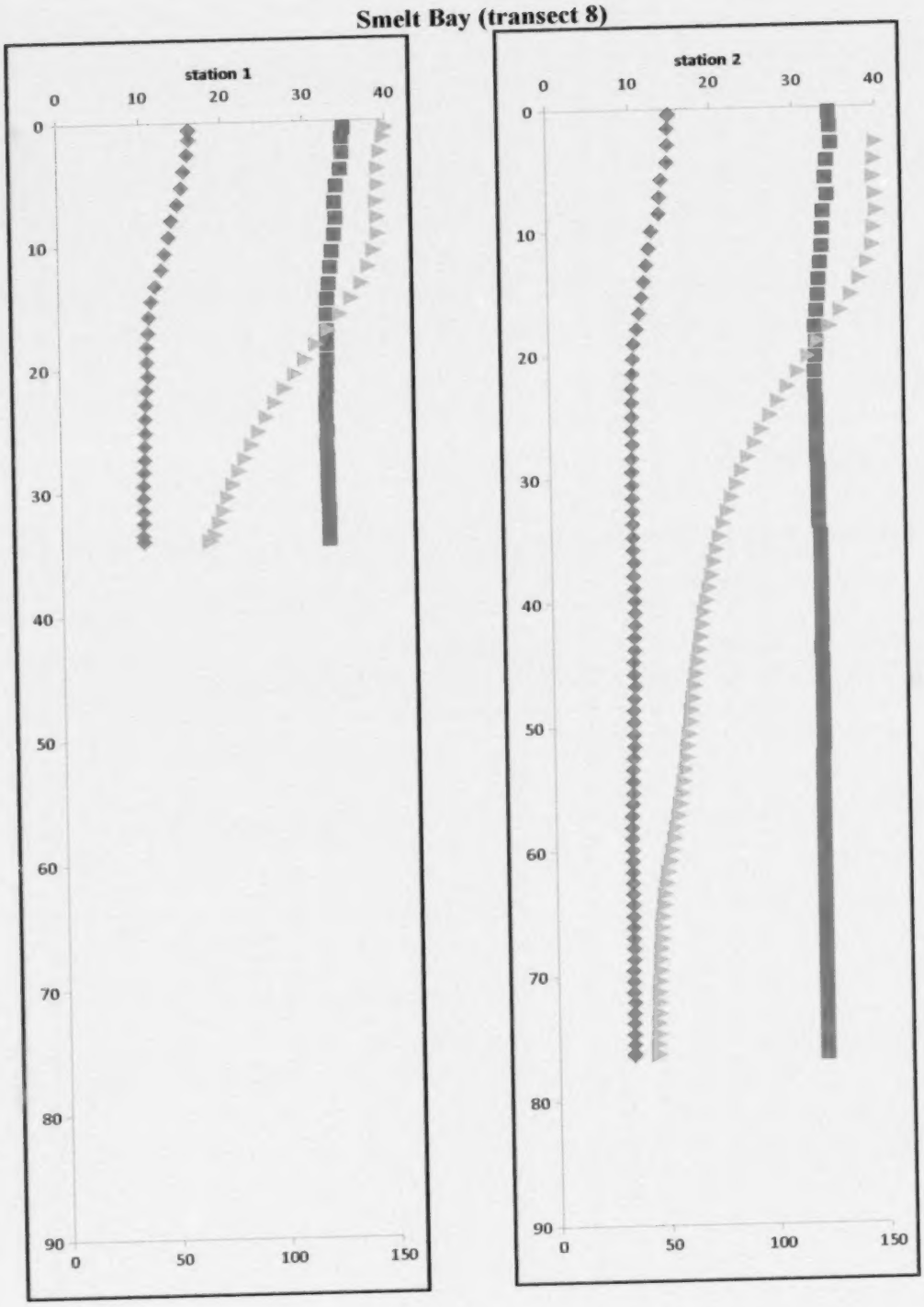

Figure 7 continued.

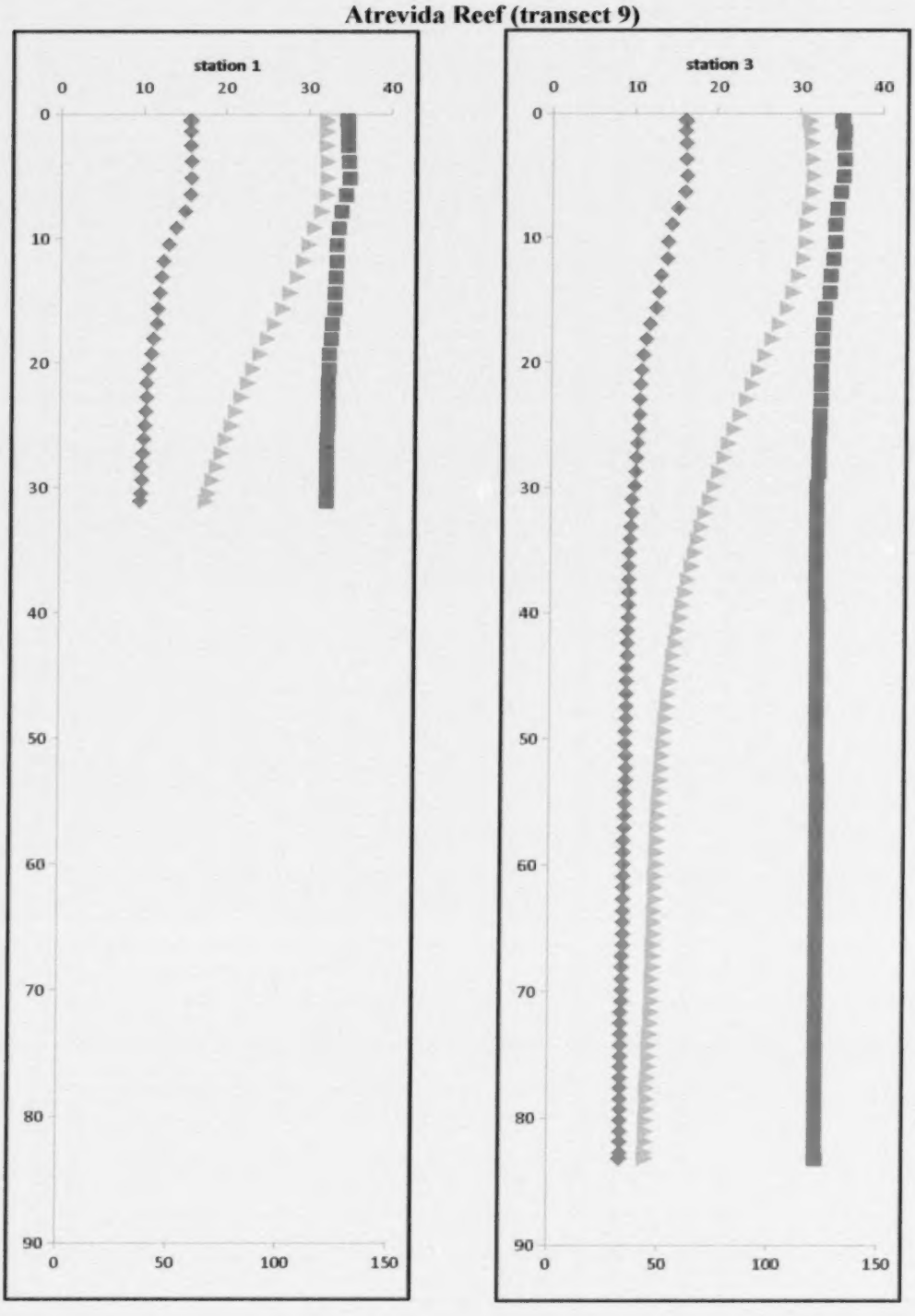

Figure 7 continued.

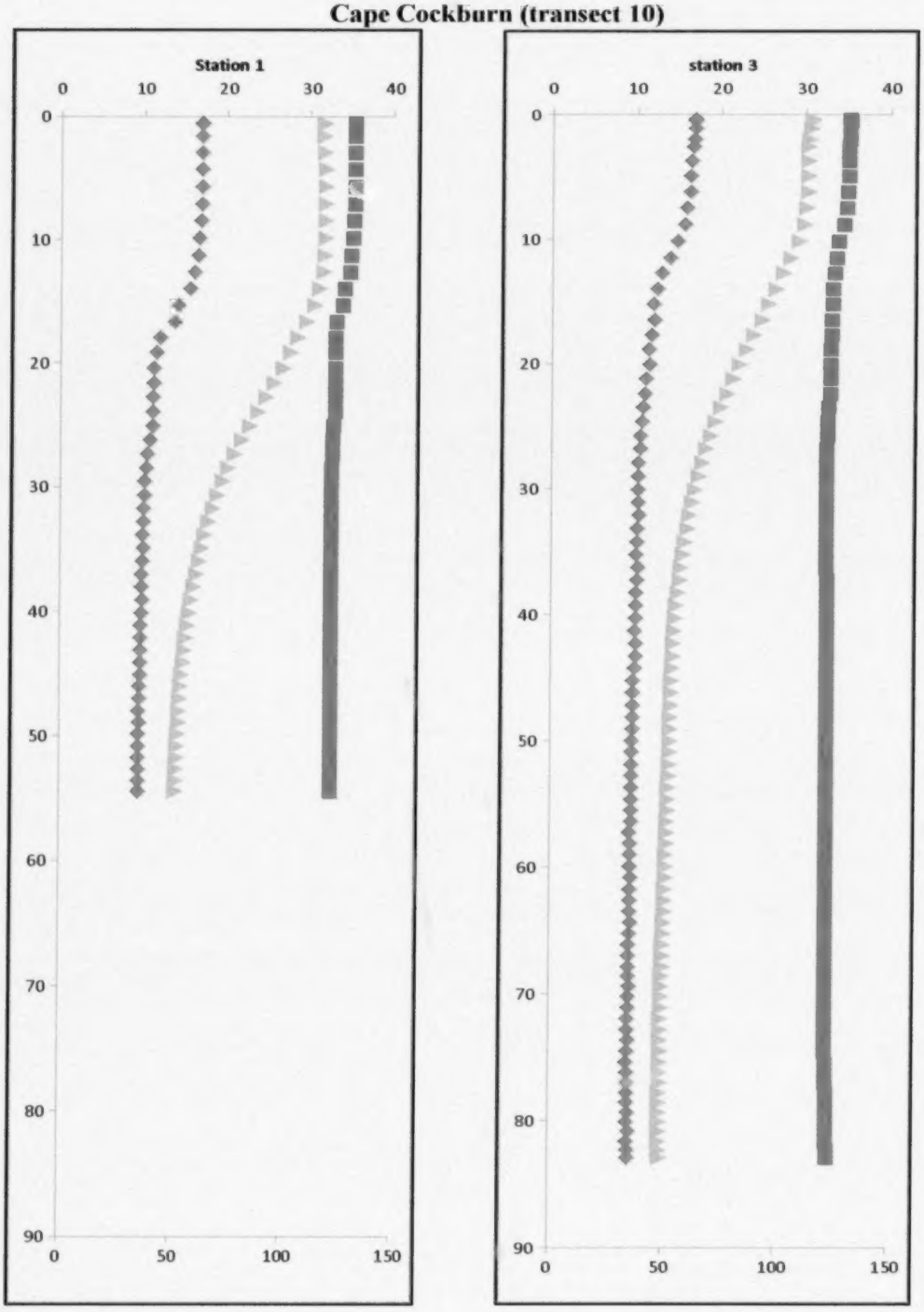

Figure 7 continued.

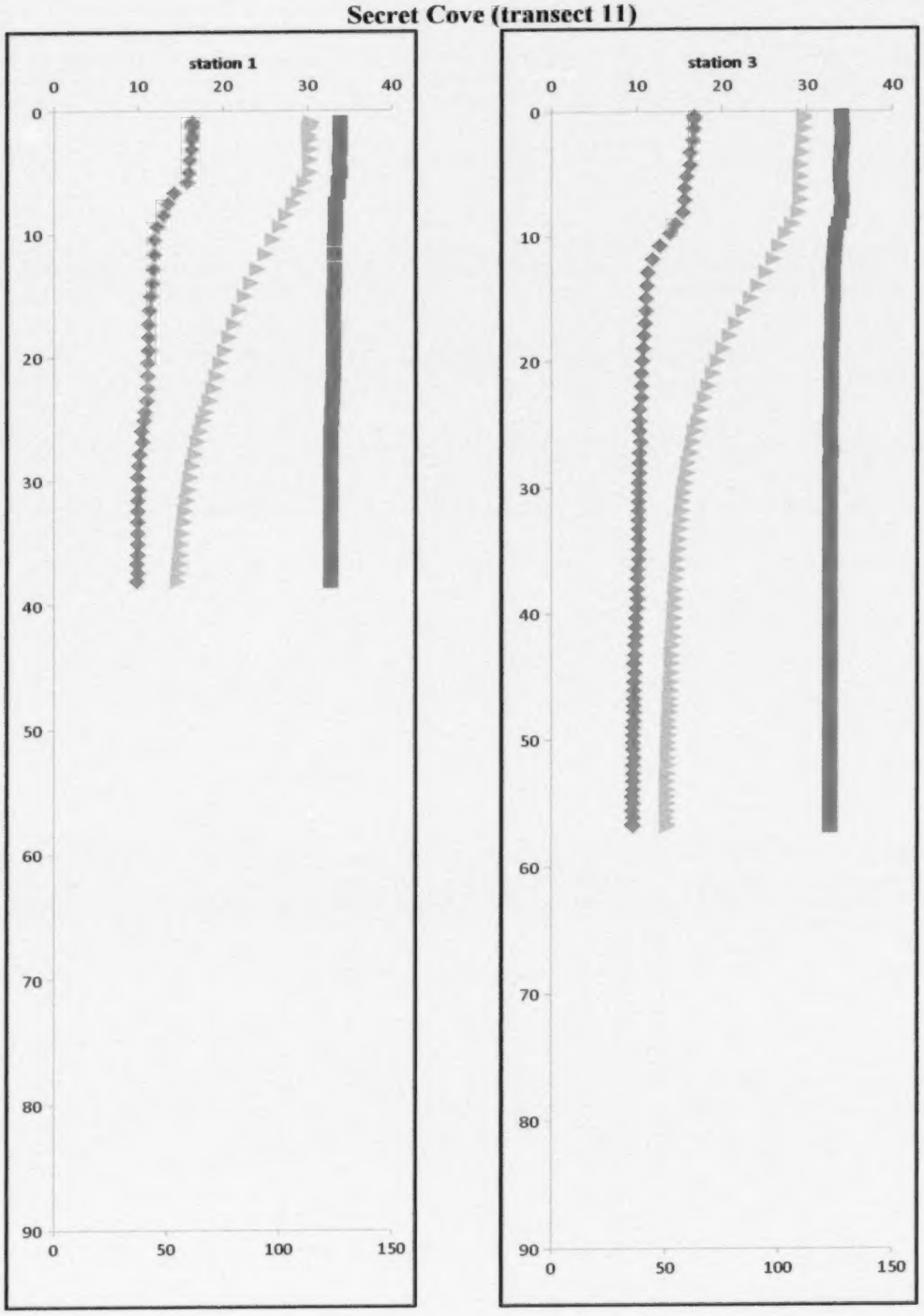

Figure 7 continued.

Table 1. Summary of the purse seine set locations from the 2014 Strait of Georgia juvenile herring survey. DD = decimal degrees.

Year	Month	Day	Transect	Station	Seine Set Time	Location Name	DD Lat (N)	DD Long (W)
2014	9	8	1	1	2100	Clarke Rock	49.224	-123.943
2014	9	8	1	2	2120	Clarke Rock	49.233	-123.932
2014	9	8	1	3	2145	Clarke Rock	49.237	-123.922
2014	9	8	1	4	2200	Clarke Rock	49.237	-123.912
2014	9	8	1	5	2220	Clarke Rock	49.238	-123.902
2014	9	9	11	5	2045	Secret Cove	49.523	-124.060
2014	9	9	11	4	2110	Secret Cove	49.527	-124.040
2014	9	9	11	3	2135	Secret Cove	49.528	-124.014
2014	9	9	11	2	2200	Secret Cove	49.532	-123.995
2014	9	9	11	1	2225	Secret Cove	49.535	-123.977
2014	9	10	10	1	2055	Cape Cockburn	49.670	-124.198
2014	9	10	10	2	2125	Cape Cockburn	49.662	-124.218
2014	9	10	10	3	2150	Cape Cockburn	49.651	-124.242
2014	9	10	10	4	2215	Cape Cockburn	49.642	-124.255
2014	9	10	10	5	2240	Cape Cockburn	49.632	-124.278
2014	9	11	8	3	2040	Smelt Bay	50.054	-125.030
2014	9	11	8	2	2100	Smelt Bay	50.046	-125.016
2014	9	11	8	1	2130	Smelt Bay	50.036	-125.000
2014	9	11	9	1	105	Atrevida Reef	49.916	-124.659
2014	9	11	9	2	130	Atrevida Reef	49.912	-124.673
2014	9	11	9	3	150	Atrevida Reef	49.909	-124.684
2014	9	11	9	4	210	Atrevida Reef	49.906	-124.694
2014	9	11	9	5	230	Atrevida Reef	49.902	-124.707
2014	9	15	4	5	2040	Henry Bay	49.602	-124.836
2014	9	15	4	4	2100	Henry Bay	49.598	-124.846
2014	9	15	4	3	2115	Henry Bay	49.598	-124.856
2014	9	15	4	2	2140	Henry Bay	49.601	-124.866
2014	9	15	4	1	2200	Henry Bay	49.593	-124.875
2014	9	17	3	1	2100	Bowser	49.452	-124.680
2014	9	17	3	2	2130	Bowser	49.459	-124.672
2014	9	17	3	3	2205	Bowser	49.467	-124.663
2014	9	17	3	4	2235	Bowser	49.476	-124.657
2014	9	17	3	5	2300	Bowser	49.482	-124.651
2014	9	19	5	5	2037	French Creek	49.366	-124.317
2014	9	19	5	4	2100	French Creek	49.362	-124.323
2014	9	19	5	3	2125	French Creek	49.358	-124.327
2014	9	19	5	2	2145	French Creek	49.353	-124.338

Table 1 continued.

Year	Month	Day	Transect	Station	Seine Set Time	Location Name	DD Lat (N)	DD Long (W)
2014	9	19	5	1	2205	French Creek	49.348	-124.350
2014	9	22	2	5	2045	Yellow Point	49.066	-123.698
2014	9	22	2	4	2120	Yellow Point	49.060	-123.708
2014	9	22	2	3	2145	Yellow Point	49.056	-123.722
2014	9	22	2	2	2215	Yellow Point	49.050	-123.733
2014	9	22	2	1	2240	Yellow Point	49.042	-123.747
2014	9	30	6	1	2030	Trincomali Channel	48.855	-123.430
2014	9	30	6	2	2055	Trincomali Channel	48.862	-123.423
2014	9	30	6	3	2120	Trincomali Channel	48.867	-123.417
2014	9	30	6	4	2140	Trincomali Channel	48.873	-123.407
2014	9	30	6	5	2200	Trincomali Channel	48.877	-123.407

Table 2. Summary of the number and weight by species, transect, and station for 2014 Strait of Georgia juvenile herring survey.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
1	1	Clarke Rock	**Pacific herring age-0+**	4464	39.86
			Pacific herring age-1+	54	1.52
			Squid	297	7.07
			Pink salmon	9	0.44
1	2	Clarke Rock	**Pacific herring age-0+**	378	3.23
			Pacific herring age-1+	6	0.16
			Squid	52	0.07
			Chum salmon	24	1.41
			Pink salmon	14	0.83
1	3	Clarke Rock	**Pacific herring age-0+**	956	8.46
			Pink salmon	32	1.70
			Chum salmon	16	0.98
			Pipefish	4	0.01
1	4	Clarke Rock	**Pacific herring age-0+**	516	4.73
			Pink salmon	24	1.37
			Chinook salmon	6	0.38
			Squid	4	0.16
			Chum salmon	2	0.31
1	5	Clarke Rock	**Pacific herring age-0+**	558	5.84
			Pink salmon	26	1.55
			Chinook salmon	4	0.19
			Three-spine stickleback	2	trace
2	1	Yellow Point	**Pacific herring age-0+**	1953	19.62
2	2	Yellow Point	**Pacific herring age-0+**	61	0.61
			Squid	201	0.75
			Three-spine stickleback	3	0.01
			Northern anchovy	1	trace
			Pink salmon	1	0.04
			Sculpin	1	0.01

* weights <0.01 Kg referred to as trace

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
2	3	Yellow Point	**Pacific herring age-0+**	70	0.69
			Squid	161	0.56
			Three-spine stickleback	2	trace
			Northern anchovy	1	trace
			Chinook salmon	1	0.05
			Midshipman	1	trace
			Walleye pollock, juvenile	1	0.01
2	4	Yellow Point	**Pacific herring age-0+**	54	0.53
			Squid	256	0.90
			Three-spine stickleback	9	0.01
			Chinook salmon	1	0.04
			Midshipman	1	0.01
2	5	Yellow Point	**Pacific herring age-0+**	161	1.58
			Squid	7	0.06
			Chinook salmon	1	0.04
			Coho salmon	1	0.06
3	1	Bowser	**Pacific herring age-0+**	604	11.99
			Pacific herring age-1+	21539	740.59
			Pacific herring age-2+	4026	252.40
3	2	Bowser	**Pacific herring age-0+**	3549	35.82
			Pacific herring age-1+	325	13.11
			Pacific herring age-2+	26	1.45
			Pink salmon	39	2.40
			Pipefish	39	0.02
			Squid	13	0.11
3	3	Bowser	**Pacific herring age-0+**	269	2.53
			Pacific herring age-1+	17	0.57
			Chum salmon	6	0.62
			Squid	6	0.03
			Pink salmon	3	0.25
			Pipefish	2	trace
			Three-spine stickleback	2	trace
			Greenling	1	0.01
			Midshipman	1	0.02

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
3	4	Bowser	**Pacific herring age-0+**	178	1.84
			Pacific herring age-1+	16	0.57
			Squid	14	0.08
			Chum salmon	2	0.17
			Coho salmon	1	0.14
			Greenling	1	0.02
			Midshipman	1	0.01
3	5	Bowser	**Pacific herring age-0+**	490	5.12
			Pacific herring age-1+	20	0.71
			Squid	38	0.20
			Pink salmon	4	0.33
			Three-spine stickleback	4	trace
			Chum salmon	2	0.26
			Midshipman	2	0.00
4	1	Henry Bay	**Pacific herring age-0+**	2607	21.19
4	2	Henry Bay	**Pacific herring age-0+**	1122	8.73
			Squid	84	0.32
			Midshipman	30	0.02
			Pipefish	12	trace
			Snake prickleback	6	0.01
4	3	Henry Bay	**Pacific herring age-0+**	1716	12.63
			Midshipman	66	0.05
			Squid	24	0.07
			Chum salmon	6	0.40
			Gunnel	6	0.03
4	4	Henry Bay	**Pacific herring age-0+**	5280	37.85
			Chinook salmon	11	1.35
			Gunnel	11	0.07
			Snake prickleback	11	0.04

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
4	5	Henry Bay	**Pacific herring age-0+**	16	0.11
			Shiner perch	52	0.40
			Squid	32	0.03
			Snake prickleback	24	0.01
			Gunnel	13	0.10
			Pipefish	2	trace
			Sculpin	2	0.07
			Chinook salmon	1	0.12
			Walleye pollock, juvenile	1	0.01
5	1	French Creek	**Pacific herring age-0+**	3	0.03
			Shiner perch	290	3.53
			Midshipman	65	0.05
			Pipefish	10	0.01
			Flatfish	6	0.14
			Walleye pollock, juvenile	3	0.02
			Squid	3	0.06
			Gunnel	2	0.02
			Walleye pollock, adult	1	0.07
5	2	French Creek	**Pacific herring age-0+**	3	0.04
			Pacific herring age-1+	1	0.03
			Pacific herring age-2+	1	0.07
			Squid	4	0.01
			Midshipman	3	0.04
			Pipefish	2	trace
			Coho salmon	1	0.07
5	3	French Creek	**Pacific herring age-0+**	1	0.01
5	4	French Creek	Pink salmon	1	0.09
5	5	French Creek	Squid	2	0.13
			Chum salmon	1	0.20
			Coho salmon	1	0.12

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
6	1	Trincomali Channel	**Pacific herring age-0+**	1	0.01
			Squid	6	0.02
			Pink salmon	4	0.19
			Coho salmon	2	0.14
			Pacific sand lance	1	trace
6	2	Trincomali Channel	**Pacific herring age-0+**	1	0.01
			Squid	4	0.01
			Pink salmon	1	0.05
6	3	Trincomali Channel	Squid	3	0.01
			Coho salmon	1	0.08
6	4	Trincomali Channel	Squid	11	0.02
6	5	Trincomali Channel	**Pacific herring age-0+**	3	0.03
			Squid	19	0.61
			Pink salmon	1	0.05
8	1	Smelt Bay	**Pacific herring age-0+**	434	3.64
			Pacific herring age-1+	6	0.20
			Pacific herring age-2+	2	0.18
			Squid	30	0.75
			Midshipman	10	0.11
8	2	Smelt Bay	**Pacific herring age-0+**	138	1.16
			Pacific herring age-1+	60	2.44
			Pacific herring age-2+	104	6.60
			Squid	22	0.06
			Northern smooth tongue	18	0.03
			Chinook salmon	4	0.22
			Midshipman	2	trace
			Walleye pollock, juvenile	2	0.01

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
8	3	Smelt Bay	**Pacific herring age-0+**	314	2.52
			Pacific herring age-1+	20	0.48
			Pacific herring age-2+	4	0.25
			Squid	24	0.38
			Midshipman	16	0.01
			Crab	4	trace
			Three-spine stickleback	4	trace
			Northern anchovy	2	trace
			Flatfish	2	0.03
			Pipefish	2	trace
9	1	Atrevida Reef	**Pacific herring age-0+**	165	1.23
			Pacific herring age-1+	2	0.05
			Squid	33	0.11
			Chinook salmon	6	0.21
			Chum salmon	5	0.34
			Three-spine stickleback	5	0.01
			Northern anchovy	4	trace
			Coho salmon	1	0.11
			Pipefish	1	trace
			Northern smooth tongue	1	trace
9	2	Atrevida Reef	**Pacific herring age-0+**	152	1.26
			Pacific herring age-1+	96	2.96
			Pacific herring age-2+	6	0.33
			Chum salmon	6	0.49
			Sockeye salmon	4	0.20
			Northern anchovy	2	0.04
			Chinook salmon	2	0.07
			Three-spine stickleback	2	trace
9	3	Atrevida Reef	**Pacific herring age-0+**	83	0.70
			Pacific herring age-1+	68	2.20
			Chum salmon	4	0.44
			Coho salmon	2	0.14
			Three-spine stickleback	2	trace

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
9	4	Atrevida Reef	**Pacific herring age-0+**	26	0.21
			Pacific herring age-1+	9	0.31
			Chum salmon	5	0.43
			Pink salmon	2	0.09
			Sockeye salmon	2	0.14
			Chinook salmon	1	0.04
9	5	Atrevida Reef	**Pacific herring age-0+**	36	0.29
			Pacific herring age-1+	9	0.30
			Pacific herring age-2+	1	0.06
			Three-spine stickleback	11	0.01
			Pipefish	7	trace
			Chum salmon	5	0.39
			Chinook salmon	3	0.11
			Sockeye salmon	3	0.17
			Coho salmon	1	0.21
10	1	Cape Cockburn	**Pacific herring age-1+**	126	3.25
			Pacific herring age-0+	124	1.17
			Pipefish	6	trace
			Squid	4	0.02
			Three-spine stickleback	4	0.01
			Pink salmon	2	0.09
10	2	Cape Cockburn	**Pacific herring age-0+**	848	8.72
			Chum salmon	20	1.64
			Coho salmon	16	0.36
			Chinook salmon	12	0.78
			Pipefish	8	trace
			Pacific lamprey	4	0.05
10	3	Cape Cockburn	Hake, juvenile	8	0.01
			Chum salmon	4	0.34
			Chinook salmon	3	0.08
			Coho salmon	1	0.17
			Pink salmon	1	0.04
			Walleye pollock, adult	1	0.46
			Northern smooth tongue	1	trace

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
10	4	Cape Cockburn	**Pacific herring age-0+**	1	0.01
			Pipefish	8	trace
			Chum salmon	4	0.23
			Hake, juvenile	4	trace
			Pink salmon	1	0.06
10	5	Cape Cockburn	**Pacific herring age-0+**	5	0.05
			Pacific herring age-1+	1	0.03
			Squid	162	0.33
			Midshipman	49	0.03
			Pipefish	8	trace
			Chinook salmon	2	0.07
			Pink salmon	2	0.10
			Chum salmon	1	0.11
			Coho salmon	1	0.10
11	1	Secret Cove	**Pacific herring age-0+**	192	1.94
			Pacific herring age-1+	48	1.49
			Three-spine stickleback	236	0.78
			Northern anchovy	148	0.32
			Walleye pollock, juvenile	52	0.29
			Chinook salmon	36	1.06
			Chum salmon	28	1.83
			Coho salmon	28	0.80
			Northern smooth tongue	12	0.02
			Squid	8	0.03
			Hake, adult	4	0.39
			Midshipman	4	trace
			Pink salmon	4	0.11
11	2	Secret Cove	**Pacific herring age-0+**	544	5.41
			Pacific herring age-1+	24	0.74
			Chum salmon	28	2.32
			Pipefish	8	trace
			Hake, juvenile	4	0.17
			Pink salmon	4	0.15

Table 2 continued.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
11	3	Secret Cove	**Pacific herring age-0+**	406	4.24
			Pacific herring age-1+	14	0.46
			Chinook salmon	4	0.13
			Chum salmon	4	0.25
			Pipefish	2	trace
			Walleye pollock, adult	2	0.14
11	4	Secret Cove	**Pacific herring age-0+**	24	0.25
			Chum salmon	7	0.65
			Chinook salmon	6	0.22
			Pink salmon	1	0.03
			Sockeye salmon	1	0.06
			Three-spine stickleback	1	trace
11	5	Secret Cove	**Pacific herring age-0+**	1	0.01
			Chum salmon	2	0.15
			Coho salmon	2	0.24
			Chinook salmon	1	0.02

Table 3. Percent occurrence by species in purse seine sets for the Strait of Georgia juvenile herring survey in 2014.

Common Name	Scientific Name	% Occurrence 2014
Pacific herring age-0+	*Clupea pallasi* in year of birth	89.6
Pacific herring age-1+	*Clupea pallasi* in first year	43.8
Pacific herring age-2+	*Clupea pallasi* in second or more years	16.7
Adult hake	*Merluccius productus*	2.1
Adult walleye pollock	*Theragra chalcogramma*	6.3
Bay pipefish	*Syngnathus griseolineatus*	33.3
Chinook salmon	*Oncorhyncus tshawytscha*	39.6
Chum salmon	*Oncorhyncus keta*	45.8
Coho salmon	*Oncorhyncus kisutch*	29.2
Crab	*Metacarcinus magister*	2.1
Flatfish	*Parophyrus vetulus, Lepidopsetta bilineata, Platichthys stellatus, Citharichthys stigmaens*	4.2
Greenling	*Hexagrammos sp.*	4.2
Gunnel	*Apodichthys flavidus, Pholis laeta*	8.3
Juvenile hake	*Merluccius productus*	6.3
Juvenile walleye pollock	*Theragra chalcogramma*	10.4
Northern anchovy	*Engraulis mordax mordax*	12.5
Pacific sand lance	*Ammodytes hexapterus*	2.1
Pink salmon	*Oncorhyncus gorbuscha*	43.8
Plainfin midshipman	*Porichthys notatus*	29.2
Sculpin	*Leptocottus armatus*	4.2
Shiner perch	*Cymatogaster aggregata*	4.2
Snake prickleback	*Lumpenus sagitta*	6.3
Sockeye salmon	*Oncorhyncus nerka*	8.3
Squid	*Loligo opalescens, Gonatus fabricii*	60.4
Three-spine stickleback	*Gasterosteus aculeatus*	29.2

* Jellyfish occurrence is not included due to the large quantities usually encountered and the inability to correctly quantify.

Table 4. Summary of the number of herring sampled, range of lengths (mm), mean length, range of weights (g), mean weight, and standard deviations for three age classes sampled during the 2014 Strait of Georgia juvenile herring survey. Total catch in numbers (N) and weight (Wt) of all herring are shown for each transect.

Age-0+ Herring			Length (mm)			Weight (g)				
Location Name	Transect	Number Sampled	Range	Mean	SD	Range	Mean	SD	N	Wt (Kg)
Clarke Rock	1	500	76-109	89	5.51	6.03-16.22	9.09	1.77	6872	62.12
Yellow Point	2	385	84-106	91	3.06	8.10-15.52	9.87	0.96	2299	23.02
Bowser	3	405	67-114	92	7.48	3.92-23.32	10.31	2.64	5090	57.29
Henry Bay	4	416	68-95	82	4.01	4.06-11.54	7.58	1.03	10741	80.51
French Creek	5	7	88-106	96	8.40	8.79-15.60	11.73	2.89	7	0.08
Trincomali	6	5	80-96	89	5.89	6.44-11.57	9.29	1.85	5	0.05
Smelt Bay	8	269	79-107	86	3.34	6.66-19.22	8.31	1.01	886	7.32
Atrevida Reef	9	321	76-114	85	5.23	5.71-22.92	7.99	1.85	462	3.69
Cape Cockburn	10	168	81-113	90	4.46	6.86-20.25	9.96	1.68	978	9.95
Secret Cove	11	273	82-113	91	4.49	7.48-20.89	10.05	1.66	1167	11.85
All locations		2749	67-114	88	6.09	3.92-23.32	9.10	1.96	28507	255.88

Table 4 continued.

Age-1+ Herring			Length (mm)			Weight (g)				
Location Name	Transect	Number Sampled	Range	Mean	SD	Range	Mean	SD	N	Wt (Kg)
Clarke Rock	1	9	122-143	129	5.95	22.80-35.70	27.87	3.82	60	1.69
Yellow Point	2	-	-	-	-	-	-	-	-	-
Bowser	3	175	117-154	136	9.98	20.56-63.62	35.32	8.73	21917	755.56
Henry Bay	4	-	-	-	-	-	-	-	-	-
French Creek	5	1	138	138	-	32.20	32.20	-	1	0.03
Trincomali	6	-	-	-	-	-	-	-	-	-
Smelt Bay	8	43	116-154	139	12.63	19.46-51.69	36.19	9.25	86	3.11
Atrevida Reef	9	136	116-154	131	7.88	22.10-52.28	31.80	5.93	184	5.82
Cape Cockburn	10	64	116-139	126	5.60	19.22-33.32	25.88	3.36	127	3.28
Secret Cove	11	25	120-151	133	8.63	23.28-42.90	31.47	6.22	86	2.69
All locations		453	116-154	133	9.72	19.22-63.62	32.65	7.93	22461	772.18

Table 4 continued.

Age-2+ Herring			Length (mm)			Weight (g)				
Location Name	Transect	Number Sampled	Range	Mean	SD	Range	Mean	SD	N	Wt (Kg)
Clarke Rock	1	-	-	-	-	-	-	-	-	-
Yellow Point	2	-	-	-	-	-	-	-	-	-
Bowser	3	22	155-174	162	6.12	50.13-82.76	62.07	9.51	4052	253.85
Henry Bay	4	-	-	-	-	-	-	-	-	-
French Creek	5	1	171	171	-	67.40	67.40	-	1	0.07
Trincomali	6	-	-	-	-	-	-	-	-	-
Smelt Bay	8	55	156-180	166	6.44	43.30-87.89	63.86	8.98	110	7.02
Atrevida Reef	9	4	155-163	160	3.56	45.97-61.04	56.52	7.07	7	0.39
Cape Cockburn	10	-	-	-	-	-	-	-	-	-
Secret Cove	11	-	-	-	-	-	-	-	-	-
All locations		82	155-180	165	6.53	43.30-87.89	63.06	9.06	4170	261.33

Table 5. Organisms by phylum, and with abbreviations, observed in zooplankton samples collected during the 2014 Strait of Georgia juvenile herring survey.

Coelenterata	
COEL	Medusae - *Aequorea victoria*
SIPH	Siphonophores
Ctenophora	
CTEN	Ctenophores
Annelida	
POLY	Polychaetes
Mollusca	
GAST	Prosobranch gastropods
PELE	Pelecypods
Arthropoda	
AMPH	Amphipods
BARN	Barnacle, unknown stage
CLAD	Cladocerans; *Podon sp.* and *Evadne sp.*
CNAU	Unidentified copepod nauplii
COPE	Copepods (see Table 9 for list of species)
CRAM	Crab megalopea, including porcillinadea
CRAZ	Crab zoea, including porcillinadea
EUPA	Adult euphausiids; mainly *Euphausia pacifica*
EUPL	Larval euphausiids; mainly *Euphausia pacifica*
INSE	Insects
MYSI	Mysids
OSTR	Ostracods
SHRI	Shrimp zoea
TRAS	*Thysanoessa raschii*
TSPI	*Thysanoessa spinifera*
Echinoderm	
ECHI	Echinoderms
Chaetognatha	
CHAE	Chaetognaths; mainly *Sagitta sp.*
Chordata	
FISHL	Fish larvae
LARV	Larvaceans; mainly *Oikopleura sp.* and some *Fritillaria sp.*
Miscellaneous	
EGGS	Unidentified eggs; either euphausiid or teleost

Table 6. Abbreviations for calanoid and cyclopoid copepods identified in the 2014 zooplankton samples from the Strait of Georgia juvenile herring survey.

Calanoid copepods	
ALON	*Acartia longiremis*
CABD	*Centropages abdominates*
CALA	*Calanus sp.*
CMAR	*Calanus marshallae*
CPAC	*Calanus pacificus*
EBUN	*Eucalanus bungii*
METR	*Metridia sp.*
MPAC	*Metridia pacifica*
OBOR	*Oncaea borealis*
PPAR	*Paracalanus parvus*
PSEU	*Pseudocalanus sp.*
SMIN	*Scolecithricella minor*
TDIS	*Tortanus discaudatus*
UCAL	Unidentified calanoid copepod

Cyclopoid copepods	
CANG	*Corycaeus anglicus*
OATL	*Oithona atlantica*
OSIM	*Oithona similis*

Table 7. Volume of water filtered and number of zooplankton per m^3 of water in samples collected during the 2014 Strait of Georgia juvenile herring survey. Species codes as shown in Tables 5 and 6.

Location	Tran	Stn	Volume (m^3)	ALON	AMPH	BARN	CABD	CALA	CANG	CHAE	CLAD	CMAR
Clarke Rock	1	1	*no sample*									
		3	15.032	-	4.1	0.5	-	71.5	14.9	0.1	-	-
Yellow Point	2	1	6.664	2.4	4.8	-	-	86.7	96.0	-	-	-
		4	2.329	-	69.1	56.2	-	1827.4	274.8	-	-	-
Bowser	3	1	4.642	1.7	27.6	193.0	-	7.3	6.9	-	1199.5	-
		3	13.521	2.4	10.7	2.4	-	48.9	27.2	-	21.3	-
Henry Bay	4	3	9.933	-	302.8	64.4	-	11.6	-	-	70.9	-
		5	2.240	-	14.3	257.2	3.6	59.8	107.2	-	142.9	-
French Creek	5	1	12.347	0.6	5.2	2.8	-	9.2	1.9	-	1.9	-
		3	16.883	1.9	3.7	0.2	-	2.5	-	-	0.2	-
Trincomali	6	1	13.079	2.4	9.8	86.9	-	52.8	48.9	-	-	-
		3	8.754	1.8	11.0	3.7	-	2.5	29.2	3.7	-	-
Smelt Bay	8	1	6.724	9.5	0.1	133.3	-	70.6	80.9	-	9.5	4.8
		2	7.568	4.2	21.1	88.8	-	291.7	12.7	0.3	4.2	25.4
Atrevida Reef	9	1	15.282	1.0	2.1	1.4	-	8.0	4.2	-	-	-
		3	15.974	4.0	7.1	1.0	-	36.1	6.0	-	-	-
Cape Cockburn	10	1	6.608	-	4.8	53.4	-	20.0	2.4	-	-	-
		3	15.447	0.5	2.1	-	-	20.8	16.1	0.8	-	-
Secret Cove	11	1	16.960	0.2	1.2	1.4	-	2.9	0.9	-	-	-
		3	16.803	-	3.4	8.1	-	42.5	-	0.4	0.5	-

Table 7 continued.

Location	Tran	Stn	CNAU	COEL	CPAC	CRAM	CRAZ	CTEN	EBUN	ECHI	EGGS	EUPA	EUPL
Clarke Rock	1	1											
		3	-	0.1	-	-	1.1	1.1	-	0.5	1.1	-	0.7
Yellow Point	2	1	14.4	81.6	-	-	-	30.9	-	-	4.8	-	19.2
		4	-	665.1	-	-	-	12.9	-	-	-	-	82.9
Bowser	3	1	3.4	13.8	-	-	0.2	13.8	-	13.8	-	-	-
		3	1.2	5.9	4.7	1.2	3.6	-	-	7.1	1.2	-	1.2
Henry Bay	4	3	3.2	19.8	-	-	-	-	-	12.9	-	-	-
		5	3.6	57.1	-	-	-	0.9	-	42.9	-	-	-
French Creek	5	1	-	9.6	-	-	0.6	3.2	-	5.2	-	-	0.6
		3	0.1	0.6	-	-	-	0.1	0.3	0.2	-	-	0.1
Trincomali	6	1	2.4	60.3	2.4	-	1.5	10.4	0.1	-	-	-	2.4
		3	11.0	4.1	-	-	-	3.9	-	-	-	-	3.7
Smelt Bay	8	1	-	14.6	-	-	4.9	10.1	-	-	257.0	-	71.4
		2	-	17.4	55.0	-	8.6	25.5	0.5	12.7	-	160.7	84.6
Atrevida Reef	9	1	1.0	1.0	-	-	-	3.1	0.1	51.4	4.2	-	3.1
		3	-	-	-	-	-	-	-	45.1	2.0	3.2	4.0
Cape Cockburn	10	1	8.2	25.0	3.6	-	4.8	9.8	0.3	4.8	4.8	1.8	4.8
		3	-	1.0	0.5	-	-	1.0	0.1	78.7	-	-	1.0
Secret Cove	11	1	-	0.9	-	-	0.5	3.8	0.1	0.5	17.0	-	0.5
		3	-	0.6	49.5	-	0.5	0.2	-	0.5	1.9	2.1	-

Table 7 continued.

Location	Tran	Stn	FISHL	GAST	INSE	LARV	METR	MPAC	MYSI	OATL	OBOR	OSIM	OSTR
Clarke Rock	1	1											
		3	-	12.8	-	27.7	11.9	-	-	1.1	-	18.1	0.5
Yellow Point	2	1	0.3	43.2	-	115.2	-	-	-	-	-	4.8	-
		4	-	41.2	-	123.7	-	-	0.4	-	-	68.7	13.7
Bowser	3	1	-	82.7	-	1461.5	-	1.3	-	-	-	10.3	-
		3	-	8.3	-	177.5	3.5	1.2	-	11.8	1.2	17.8	-
Henry Bay	4	3	-	-	-	6.4	-	-	-	-	-	56.4	-
		5	-	14.3	-	1257.2	-	-	-	-	-	92.9	-
French Creek	5	1	-	19.4	-	72.6	-	-	-	-	1.9	34.3	-
		3	-	5.7	-	3.9	25.4	-	-	11.4	-	7.1	-
Trincomali	6	1	-	31.8	-	56.3	-	-	-	3.7	-	4.9	-
		3	-	7.3	0.1	263.2	-	-	-	-	-	1.8	-
Smelt Bay	8	1	-	42.8	-	252.2	0.7	-	-	-	-	9.5	-
		2	-	59.2	-	498.9	-	33.8	-	-	-	12.7	-
Atrevida Reef	9	1	-	7.4	-	35.6	4.6	-	4.4	11.0	-	15.7	-
		3	-	17.0	-	30.0	13.5	2.0	-	-	-	52.1	-
Cape Cockburn	10	1	-	4.8	-	547.3	2.0	-	-	2.4	3.6	44.8	-
		3	-	4.1	-	1.0	3.5	-	-	0.5	-	34.7	-
Secret Cove	11	1	-	-	-	39.6	-	-	-	0.7	-	1.9	-
		3	-	-	-	8.6	-	25.7	-	1.9	-	5.7	-

Table 7 continued.

Location	Tran	Stn	PELE	POLY	PPAR	PSEU	SHRI	SIPH	SMIN	TDIS	TRAS	TSPI	UCAL
Clarke Rock	1	1											
		3	-	0.5	32.6	55.3	0.5	1.1	-	-	-	-	-
Yellow Point	2	1	-	81.6	23.7	2.4	-	276.4	-	-	-	-	-
		4	-	27.5	151.1	-	55.0	264.1	-	-	-	-	-
Bowser	3	1	-	-	220.4	-	55.1	-	-	-	-	-	7.3
		3	-	1.2	131.2	35.4	1.3	1.2	-	-	-	0.1	-
Henry Bay	4	3	38.7	438.1	3.2	2.9	67.7	68.7	-	61.2	-	-	-
		5	14.3	57.1	114.7	7.6	-	115.6	-	3.6	-	-	-
French Creek	5	1	0.6	1.3	23.8	3.3	2.6	-	-	-	-	-	-
		3	0.5	0.1	2.7	15.5	0.2	0.1	0.5	-	-	0.6	-
Trincomali	6	1	1.2	3.7	48.2	18.8	3.7	18.4	-	-	-	-	-
		3	-	36.7	81.1	60.7	3.8	0.1	-	-	-	-	-
Smelt Bay	8	1	4.8	9.5	185.8	-	0.3	15.9	-	-	-	-	-
		2	-	25.5	71.9	4.2	9.0	34.9	-	-	-	-	-
Atrevida Reef	9	1	-	-	9.1	25.3	7.3	1.0	-	-	-	-	-
		3	1.0	-	67.1	65.6	1.1	0.1	-	-	-	0.1	-
Cape Cockburn	10	1	4.8	9.7	45.1	20.0	-	5.0	-	-	-	-	-
		3	2.1	21.0	21.1	17.8	-	2.1	2.6	-	-	-	-
Secret Cove	11	1	0.5	-	15.0	1.4	0.9	1.9	0.2	-	-	-	-
		3	3.3	2.8	9.5	14.6	1.0	2.4	1.9	-	0.1	0.1	-